AD-A172 051 AIRCREW AUTOMATED ESCAPE SYSTEMS (AAES) IN-SERVICE USAGE DATA ANALYSIS PROGRAM(U) NAVAL AIR SYSTEMS COMMAND WASHINGTON DC F C GUILL FEB 82 1/4

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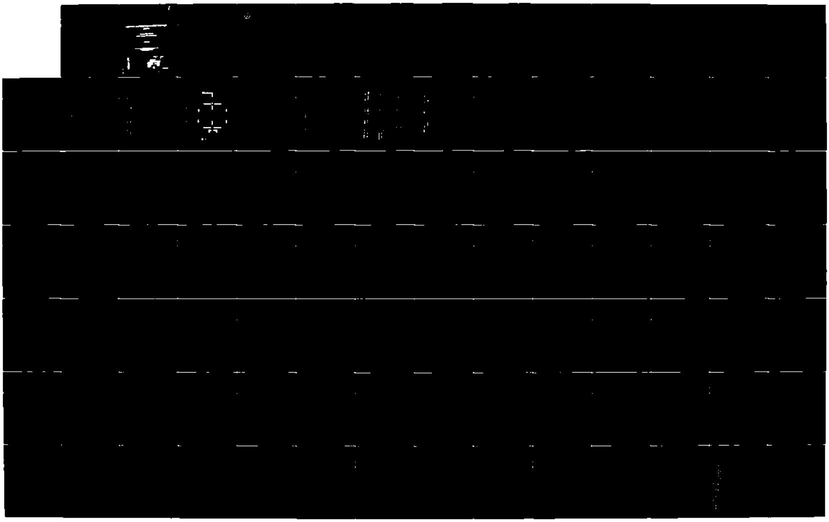

AD-A172 051

AIRCREW AUTOMATED ESCAPE SYSTEMS (AAES)

IN-SERVICE USAGE DATA ANALYSIS PROGRAM

PAPERS

PRESENTED AT SEVENTEENTH ANNUAL FAILSAFE MEETING
NAVAL REGIONAL MEDICAL CENTER
CORPUS CHRISTI, TEXAS

8-12 FEBRUARY 1982

DEPARTMENT OF THE NAVY
NAVAL AIR SYSTEMS COMMAND
WASHINGTON, D.C. 20361

IN REPLY REFER TO
5311:JAB
Ser 82/1

JAN 07 1982

From: Commander, Naval Air Systems Command
To: Commanding Officer, Naval Weapons Engineering Support Activity
Washington, DC 20390
ATTN: Fred Guill

Subj: FAILSAFE Mtg, participation in

Ref: (a) Telecon between NAVAIR (CDR Brady and Mr. Guill) and NAVWESA (Mr. Stokes) of 22 Dec 1981

1. The Naval Air Systems Command is sponsoring the 1982 FAILSAFE meeting, Feb 8-12, 1982 at NAVREGMEDCEN Corpus Christi, TX. This meeting is intended to update Naval Aerospace Physiologists in Aviation Life Support Systems (ALSS) programs under the cognizance of NAVAIR. Of special interest to this group is the ongoing analysis of automated emergency escape systems and related aircrew life support systems being conducted at NAVWESA.

2. Confirming reference (a), it is requested that NAVWESA (AAES Data Analysis Team) present a discussion of the initial data analysis program, provide analyses of U.S. Navy AAES in-service usage, and review problems commonly encountered in the statistical analysis of data similar to AAES data. Details can be discussed directly with CDR J. Brady, AIR-5311, at 692-3645.

L. J. Chrans

CDR L. J. Chrans
By Direction

AIRTASK/WORK UNIT ASSIGNMENT
NAVAIR FORM 3930/1 (REV. 2-77)

DEPARTMENT OF THE NAVY
NAVAL AIR SYSTEMS COMMAND
WASHINGTON, D.C. 20361

See NAVAIR 3900.8 or superseder for applicable details on completing this form.

CLASSIFICATION: UNCLASSIFIED

05 NOV 1980 PAGE 1 OF 3

ADDRESSEE: Director, Naval Weapons Engineering Support Activity, Systems Analysis Dept. (ESA-31), Washington Navy Yard, Wash.D.C. 20374	AIRTASK NO.: A512-512C/184-4/1512-000-055	AMEND. NO.
	WORK UNIT NO.: A5312B-04	AMEND. NO.
NAVAIR PROJECT ENGINEER: Mr. Frederick C. Guill, AV 222-7486 — CODE: AIR-531C	EFFORT LEVEL: NORMAL	
	CLASSIFICATION OF AT/WU: UNCLASSIFIED	

1. The XXXXXXXWORK UNIT ASSIGNMENT described below is assigned in accordance with the indicated effort level and schedule. Funding authorization for XXXXXXX will be provided in separate correspondence. If this XXXXXXXWORK UNIT ASSIGNMENT cannot be accomplished as assigned, advise the NAVAIR HQ cognizant code. No work beyond the planning phase will be accomplished unless the addressee has funds in hand or written assurance thereof.

2. Cancellation, References and/or Enclosures.

Cancellation: Work Unit A5312B-04 dated 13 Dec 1979 and subsequent amendments under AIRTASK A512-512C/184/0512-000-055 amend. 1.

Encl: (1) NAVAIR Consolidated Priority List - Aircraft Systems Fleet Support Projects 10 October 1980
(2) Schedule

3. Technical Instructions.

a. Title. IDENTIFICATION AND REVIEW OF AIRCREW AUTOMATED ESCAPE SYSTEM (AAES), IN-SERVICE RELIABILITY AND MAINTAINABILITY PROBLEMS

b. Purpose. To establish a systematic investigation of in-service AAES data, such as that contained in the 3-M System, Unsatisfactory Reports, Medical Officer Reports of Aircraft Accidents, and Naval Air Rework Facility Data Systems, to identify for potential corrective action the many daily low-grade problems which contribute to the general lowering of AAES in-service reliability and cause the general worsening of AAES in-service maintainability.

c. Background. At present there exist special arrangements for investigating and correcting spectacular AAES in-service problems, particularly those which cause fatalities. This effort is intended for reviewing the pervasive non-spectacular low-grade AAES in-service reliability and/or a general degradation of AAES in-service maintainability. These problems, vastly overshadowed by the spectacular ones, nonetheless are important, and if left unmonitored and uncorrected, occasionally manifest themselves in fatalities, serious injuries and/or very great difficulties experienced by the ejectee, which under slightly different conditions could have caused serious injuries. Some problems also manifest themselves in increased

SIGNATURE (By Direction COMNAVAIR)	DATE
W. R. Burris — W. R. BURRIS By direction	11/5/80

CLASSIFICATION AND GROUP MARKING: UNCLASSIFIED

Previous issues of this form are obsolete.

W.U. A5312B-04
AIRTASK A512-512C/184-4/1512-000-055

maintenance efforts and costs and/or increased hazards to maintenance personnel. Since there at present is no systematic review of in-service AAES data, there is no valid method of identifying AAES in-service problems deserving management attention short of awaiting death, serious injury or major complaints. Thus NAVAIR is forced into a "squeaky wheel" reaction mode of operation versus the more desirable mode of allocating resources based on a continuous analysis of the total AAES in-service experience.

d. Detailed Requirements/Cost Estimates. $90.0 K for FY-81 in support of applicable projects listed on enclosure (1) Priority List, to be obligated quarterly as follows: first quarter $30.0 K, second quarter $30.0 K, third quarter $30.0 K. Program element - 78012N (O & MN).

Continue establishment of a system for the systematic review of such sources of AAES in-service data as 3-M Systems, Unsatisfactory Reports, Medical Officer Reports of Aircraft Accidents, and Naval Air Rework Facility data systems, in a manner designed to identify and assess the significance of the many commonly occuring in-service problems affecting AAES in-service reliability and maintainability. The system outputs shall be structured to provide data of assistance to NAVAIR Headquarters in the management of the scarce AAES resources; e.g., problems experienced, frequency of occurrence, experience severity, potential severity, and range of activities and/or AAES experiencing the problems. Once established and documented the system(s) can be integrated into regular reporting systems to assure regular, early notification to NAVAIR Headquarters concerning in-service problems being experienced and should assist considerably in the identification of causes and development of remedial actions. In addition, perform specific analytical tasks of high priority as assigned.

e. Detailed Program Plan. Not applicable.

f. Field Activity Contact. Mr. G. Opresko, NAVWESA (ESA-31).

g. Headquarters Technical Support. None.

4. Schedule. See Enclosure (2).

5. Reports and Documentation.

a. Reports.

(1) Upon completion of each task, present data and findings in letter-type reports to NAVAIR Headquarters (AIR-531).

(2) A semi-annual program review shall be held at NAVAIR in February and August with NAVAIR publishing a report of findings in March and September.

W.U. A5312B-04
AIRTASK A512-512C/184-4/1512-000-055

(3) NAVWESA shall report to the Commander, Naval Air Systems Command (AIR-512C) the man years and associated cost, cost of materials, travel and cost of contracts awarded by NAVWESA for this project. This report shall be submitted 1 May 1981 and 1 November 1981 for final status.

b. Requirements for Future Planning Information. Prepare and submit to NAVAIRHQ (AIR-531) for approval, a letter-type project plan. The primary effort shall be for establishment of baseline data to aid in subsequent identification of trends and specific problems. Subsequent tasks shall be for extending previous analytical techniques and data sources investigating efforts to identify specific AAES in-service reliability and maintainability problems.

6. Contractual Authority. Contracts to perform all or portions of the Work Unit are hereby authorized within the funding indicated by the Work Unit cost estimate.

7. Source and Disposition of Equipment. Not applicable.

8. Aircraft Requirements. None.

9. Status of Applicable Funds. Funds for this Work Unit will be provided separately.

10. Security Classification. All prescribed work under this Work Unit is unclassified. In performing the prescribed work, access to information which is classified and/or to areas containing classified equipment may be required. Any reference to such classified material shall be in accordance with the applicable materials security classification. Particularly, reference to information concerning survivability/vulnerability shall be classified in accordance with OPNAVINST. C5513.2A, Encl. (63); OPNAVINST. S5513.8, Encl. (7).

Copy to:
Addressee (3)
NAVMATDATASYSGRU, Morgantown, W.Va. 26505
NAVAIRDEVCEN (CSD),Warminster
NAVAIRTESTCEN (SY-70), PAXRIV
NAVORDSTA (Code 5123), Indian Head
NAVORDSTA (Code 515), Indian Head
NAVWPNCEN, China Lake (Code 64)
NAVSAFECEN, Norfolk
COMNAVAIRPAC, North Island
CGFMFLANT
CGFMFPAC
NAVPLANTREPO, Bethpage
NAVPLANTREPO, Dallas
NAVPLANTREPO, Burbank
NAVPLANTREPO, Long Beach
AFPRO, St. Louis
DCASMA (DCRA-GACB), Marietta

PREFACE

The papers presented herein represent part of the growing preliminary results of work being performed by the Naval Weapons Engineering Support Activity under tasking assigned by the Crew Systems Division (AIR-531), Naval Air Systems Command to analyze in-service usage data concerning U.S. Navy aircrew automated escape systems (AAES) and, under a subtasking aimed at enhancing the quality and quantity of future data while simplifying the work of investigators/report prepares, by the Naval Aerospace Medical Research Laboratories.

These papers, however, could not have been prepared without the generous assistance provided by personnel of the Naval Safety Center, Norfolk, who created the necessary data tapes and provided guidance and counseling to the program team concerning the many nuances and pitfalls in the data. Especially helpful among the many have been Mr. Hardy Purefoy and Mrs. Betty Weinstein (Aviation Mishap Records Branch), Lcdr. Richard Moe and Mrs. Sharon Thornton (Life Support Equipment Branch), and Capt. Trostle, Lcdr. Robert Bason, and Mrs. Jean Connery (Aeromedical Division). Major support also was provided by the Life Support Engineering Division, Aircraft and Crew Systems Technology Directorate, Naval Air Development Center, Warminster, and the Aircrew Systems Branch, Naval Air Test Center, Patuxent River.

Acknowledgement also is due to the Graphics Section, Publications Department of MANTECH International, especially Miss Dorothy Thomas, who created the majority of the illustrations employed in the volume.

The Naval Weapons Engineering Support Activity personnel contributing to these papers were Mr. Charles Stokes (ESA-31I, team leader), Mrs. Myrtice Roberson, Mr. John Vetter, Mr. Larry Lewis, and Mr. Tom Henke. Without the many drafts prepared under tight deadlines by Miss Sandi Dorwart a large portion of this report would remain unpublished today. Papers also were contributed by Lcdr. Felix Palmer, Naval Aerospace Medical Research Laboratories.

The Crew Systems Division sponsor for this program is Mr. Frederick Guill (AIR-531C).

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ANALYTIC TECHNIQUES

Problems With the Use of Precentages In The Analysis of AAES Data

Problems In Statistically Analyzing AAES Data

ANALYSES

Preliminary Overview Analyses of U.S. Navy Aircrew Automated Escape System (AAES) In-service Usage Data

Preliminary Generalized Thoughts Concerning Jettisoned vs Through-the-Canopy Ejection Escape Systems

An Analysis of the Fatality Rate Data From "Jettisoned-Canopy" and "Through-Canopy" Ejections From Automated Airborne Escape Systems

Preliminary Generalized Thoughts Concerning Ejection Flail Phenomena

Preliminary Analyses of Flail, Windblast and Tumble Problems and Injuries Associated With Usage of U.S. Navy Aircrew Automated Escape Systems (AAES)

MISHAP INVESTIGATION/REPORTAGE

The Flight Surgeon's Report (FSR) From a Data User's Viewpoint

Aircrew Life Support Systems (ALSS), Post Emergency Usage Investigation Guides

Part I: Aircrew Protective Helmets
Part II: Oxygen Equipment, man-mounted

Aircrew Life Support Equipment Post-Usage Investigation/Reportage Generic Decision Tree

BIOGRAPHICAL SKETCHES OF AUTHORS

INTRODUCTION

U.S. Navy
Aircrew Automated Escape Systems (AAES)
In-Service Data Analysis Program

Frederick C. Guill and Charles W. Stokes

INTRODUCTION

The purpose of this session is both to acquaint the audience with the Naval Air Systems Command's on-going Aircrew Automated Escape System (AAES) In-service Usage Data Analysis Program and to disseminate initial data summaries and preliminary analyses, especially as concerns U.S. Navy success rates, comparison of through-the-canopy and jettisoned-canopy ejections, and ejection associated flail and flail injury experience.

This program is being developed to "establish a systematic investigation of in-service AAES data, such as contained in the 3-M System, Unsatisfactory Reports, Medical Officer Reports of Aircraft Accidents, and Naval Air Rework Facility Data Systems, to identify for potential corrective action the many daily low-grade problems which contribute to the general lowering of AAES in-service reliability and cause the general worsening of AAES in-service maintainability." (Figure 1). Until this program was established the only arrangements for investigating AAES problems were created especially "for investigating and correcting spectacular AAES in-service problems, particularly those which cause fatalities. This effort is intended for reviewing the prevasive non-spectacular low-grade AAES in-service reliability (problem) and/or a general degradation of AAES in-service maintainability. These problems, vastly overshadowed by the spectacular ones, nonetheless are important, and if left unmonitored and uncorrected, occasionally manifest themselves in fatalities, serious injuries and/or very great difficulties experienced by the ejectee, which under slightly different conditions could have caused serious injuries. Some problems also manifest themselves in increased maintenance efforts and costs and/or increased hazards to maintenance personnel."

The program has been operational for two years and, as depicted in Figure 2, remains in its formative stages. In October 1981 a two day symposium was convened during which preliminary data presentation formats and analyses were furnished to attending representatives of the escape systems community.

THE PROBLEM

The basic problem confronting the Crew Systems Division (AIR-531), Naval Air Systems Command, is the effective management of limited resources to enhance aircrew safety and performance thereby contributing to the Navy's ability to perform its assigned missions. A major element of the problem has been identifying and selecting problems for resolution. This element has been especially difficult due to the nature of the information available to AIR-531, the dynamic nature of the Navy's escape systems inventory and the time lags between introduction of equipment or fixes and the availability of information suitable for determining how well it is performing and, if improvement is necessary, the availability of material for effecting improvement (Figure 3). It has not been uncommon for problems to be defined in terms of newly developed concepts and hardware irrespective of the actual needs of the Fleet. Nor has it been uncommon for identified needs to change dramatically as the escape systems inventory mix changes. Thus, for example, major efforts were directed in the early 1960's to developing means for making survivable aircraft impact with water during ditching, following cold cat shots, following aircraft falling off carrier decks and similar carrier vicinity type water impact situations. In the late 1950s through early 1960s a large number of aviators were lost following such accidents and action was initiated to ameliorate the impact effect upon the crew. By the latter half of the 1960s, however, the problem magnitude had declined to virtual insignificance as the escape system inventory mix shifted to seats which provided sufficient capability for pre-impact ejection. Today a major problem is the post-low level ejection in-water survival, particularly when near the powerful and large wake of the carrier.

Thus the system being developed under this project involves review and analyses of today's systems' problems coupled with review and analyses of the probable impact that expected inventory changes (including engineering changes already underway) and potential aircraft operational changes might have on the identified problems in the future (Figure 4). It is expected that marriage of these analyses with schedule and cost estimates for accomplishing resolution of identified problems will enhance AIR-531's ability to prioritize problems and to project and justify its needs for resources.

Figure 5 illustrates a typical data chain, that for FSRs (Flight Surgeons' Reports), developing the data to be employed in the analyses conducted under this program. Figure 6 depicts some of the expected potential uses of the analyses in attempting to resolve AAES problems and to reduce the risks associated with AAES usage, maintenance and ownership. Much of the data examined is acquired, maintained and furnished by the Naval Safety Center, Norfolk. The Naval Safety Center, as depicted in Figure 7, in addition to providing the data for analyses, has an active and important role in defining the program's investigation taskings.

FUTURE PLANS

During 1982 the major thrust of this program will be to develop data presentation formats and analyses which, as the data base is updated, will automatically reflect the added data. As a result of resource limitations only a limited effort can be mounted towards actually defining the in-service problems and their causal factors. This relative priority between enhancing program capability and identifying Fleet problems is necessary to reduce the excessive manual labor involved in developing problem analyses today and also to ensure achieving reproducible results. This project, again, is aimed primarily at developing a management tool for Crew Systems Division use in optimally managing its AAES resources. Secondarily this program will result in greater knowledge for the entire AAES community concerning all components of the AAES (Figure 8) and ultimately in reduced risks of usage, maintenance and ownership.

REFERENCES

1. Naval Air Systems Command AIRTASK No A512-512C/184-4/1512-000-055, Work Unit No. A5312B-04 dtd 5 Nov 80 to Naval Weapons Engineering Support Activity, entitled: Identification and Review of Aircrew Automated Escape Systems (AAES) In-Service Reliability and Maintainability Problems.

2. Ibid.

AIRCREW AUTOMATED ESCAPE SYSTEMS (AAES) IN-SERVICE USAGE DATA ANALYSIS PROGRAM

PURPOSE

- ESTABLISH A SYSTEMATIC INVESTIGATION OF IN-SERVICE AAES DATA
  - —MOR/FSR (MEDICAL OFFICER'S REPORTS/FLIGHT SURGEON'S REPORTS)
  - —3M- (MAINTENANCE & MATERIAL MANAGEMENT SYSTEM)
  - —UR (UNSATISFACTORY REPORTS)
  - —AAR/MIR (AIRCRAFT ACCIDENT REPORT/MISHAP INVESTIGATIVE REPORT)

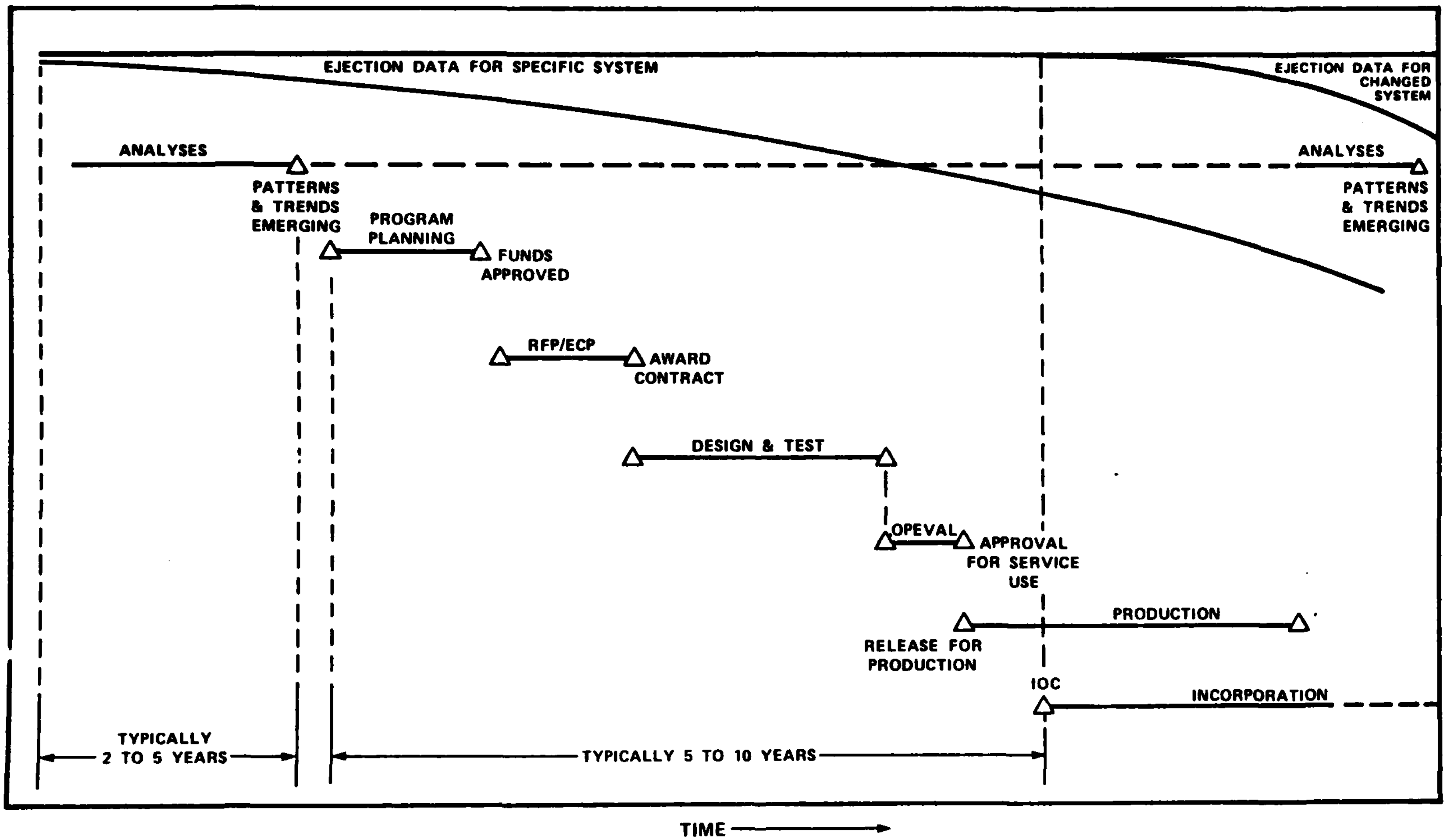
- INDENTIFY PERVASIVE LOW-GRADE, NON-SPECTACULAR PROBLEMS WHICH:
  - —LOWER AAES IN-SERVICE RELIABILITY
  - —WORSEN AAES IN-SERVICE MAINTAINABILITY
  - —MAY RESULT IN FATALITIES, SERIOUS INJURIES OR DIFFICULTIES

- EXAMINE EFFECTS OF DESIGN AND DESIGN CONCEPT CHANGES UPON
  - —AIRCREW SAFETY
  - —SYSTEM MAINTAINABILITY
  - —SYSTEM RELIABILITY
  - —GROUND CREW SAFETY

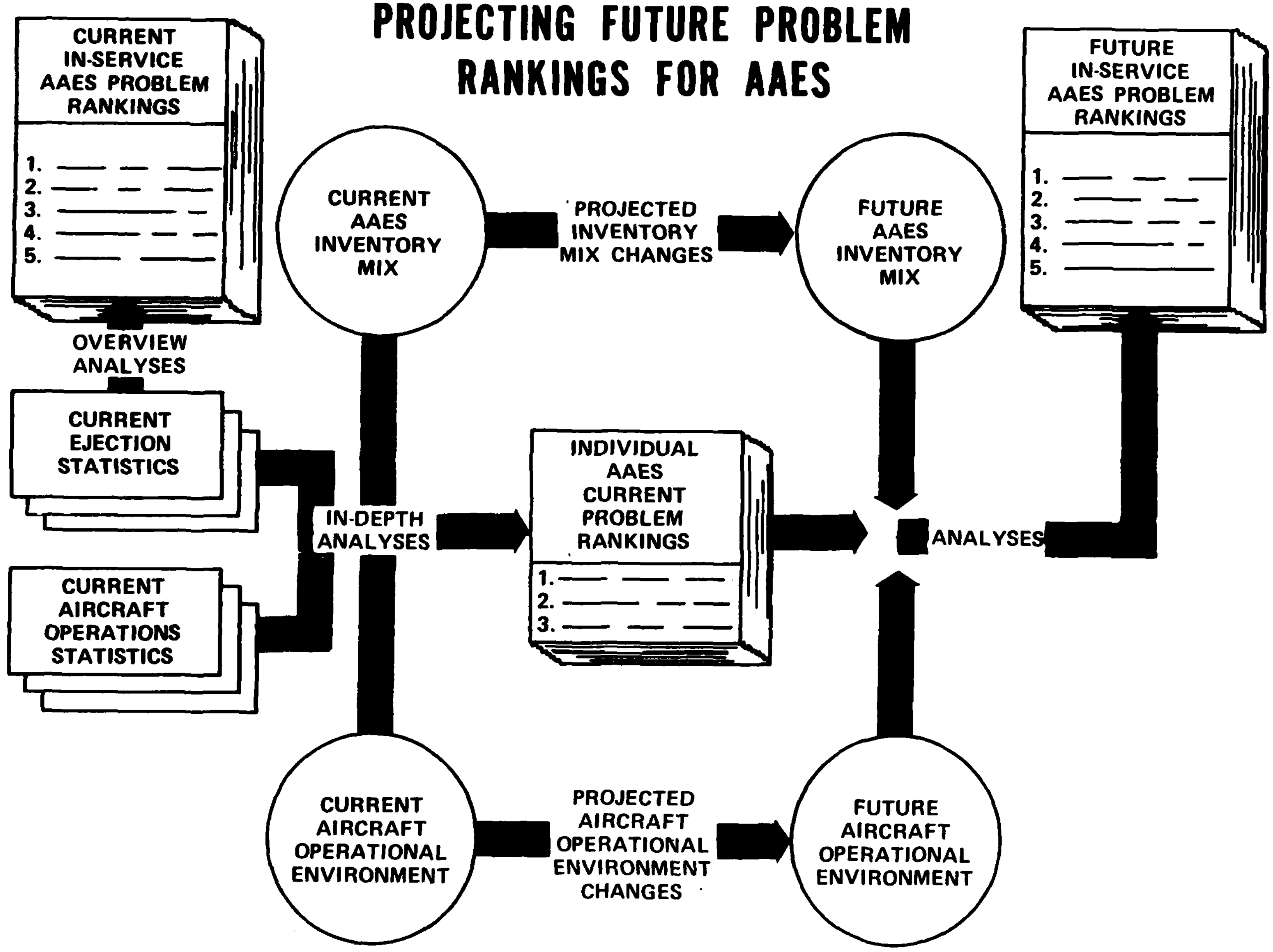
AAES IN-SERVICE USAGE DATA ANALYSES PROGRAM IS IN EARLY STAGES:

- INITIAL ACQUAINTANCE WITH AAES EQUIPMENTS/TECHNIQUES
- INITIAL ACQUISITION OF DATA
- INITIAL ACQUAINTANCE WITH DATA
- FORMULATE DATA ANALYSES TECHNIQUES AND PRESENTATION FORMATS
- ACQUIRE PRE-1969 DATA
- UPDATE DATA
- DEVELOP ROUTINE, PERIODIC AUTOMATIC ANALYSES TECHNIQUES AND PRESENTATION FORMATS
- CONDUCT SPECIAL ANALYSES

AIRCREW AUTOMATED ESCAPE SYSTEM DATA ANALYSES AND PROCUREMENT CYCLES



DATA INPUTS AND FLOW FOR PROJECTING FUTURE PROBLEM RANKINGS FOR AAES



AAES DATA CHAIN

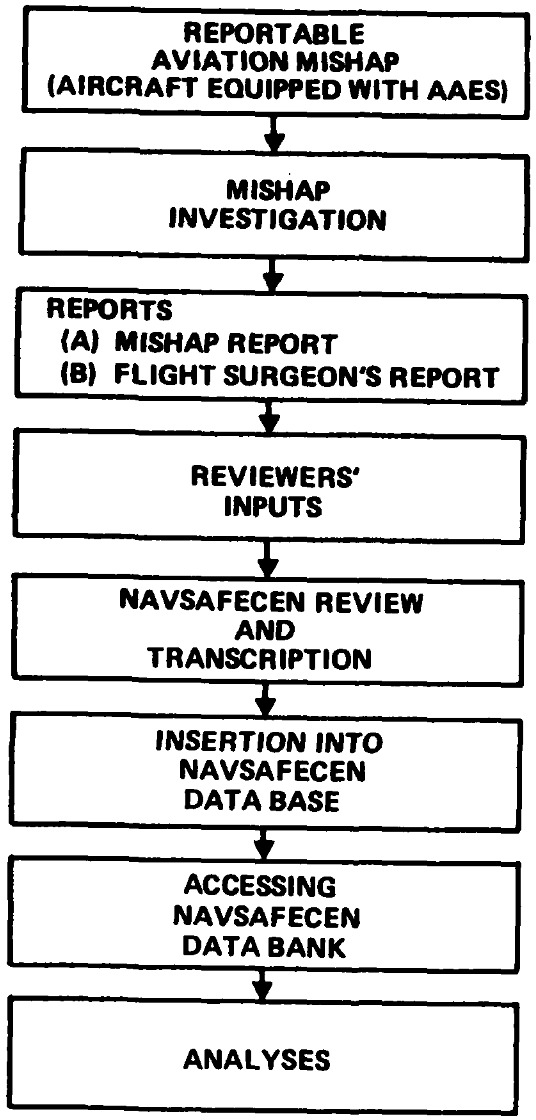


Figure 5

AAES DATA ANALYSES USAGES

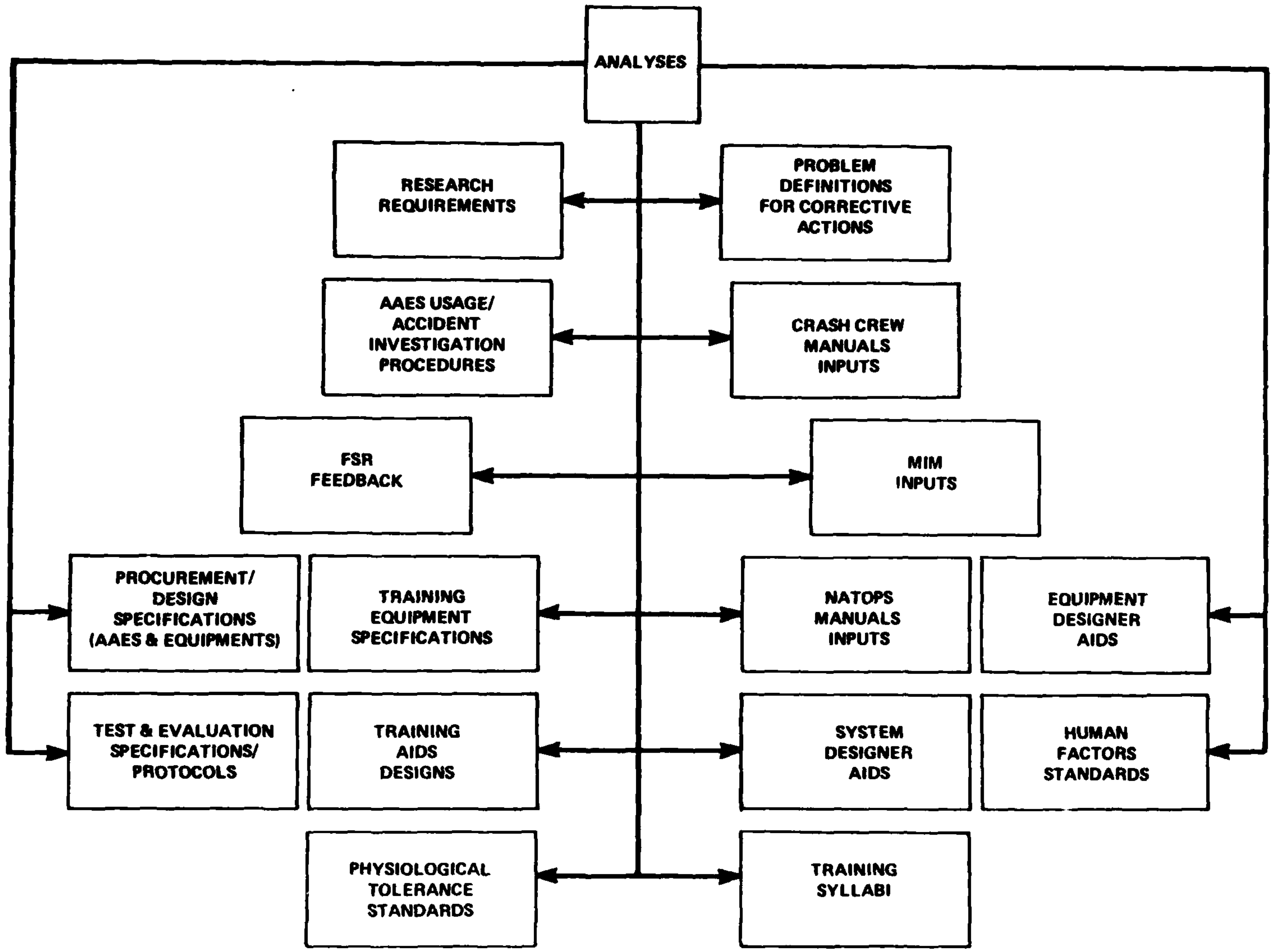
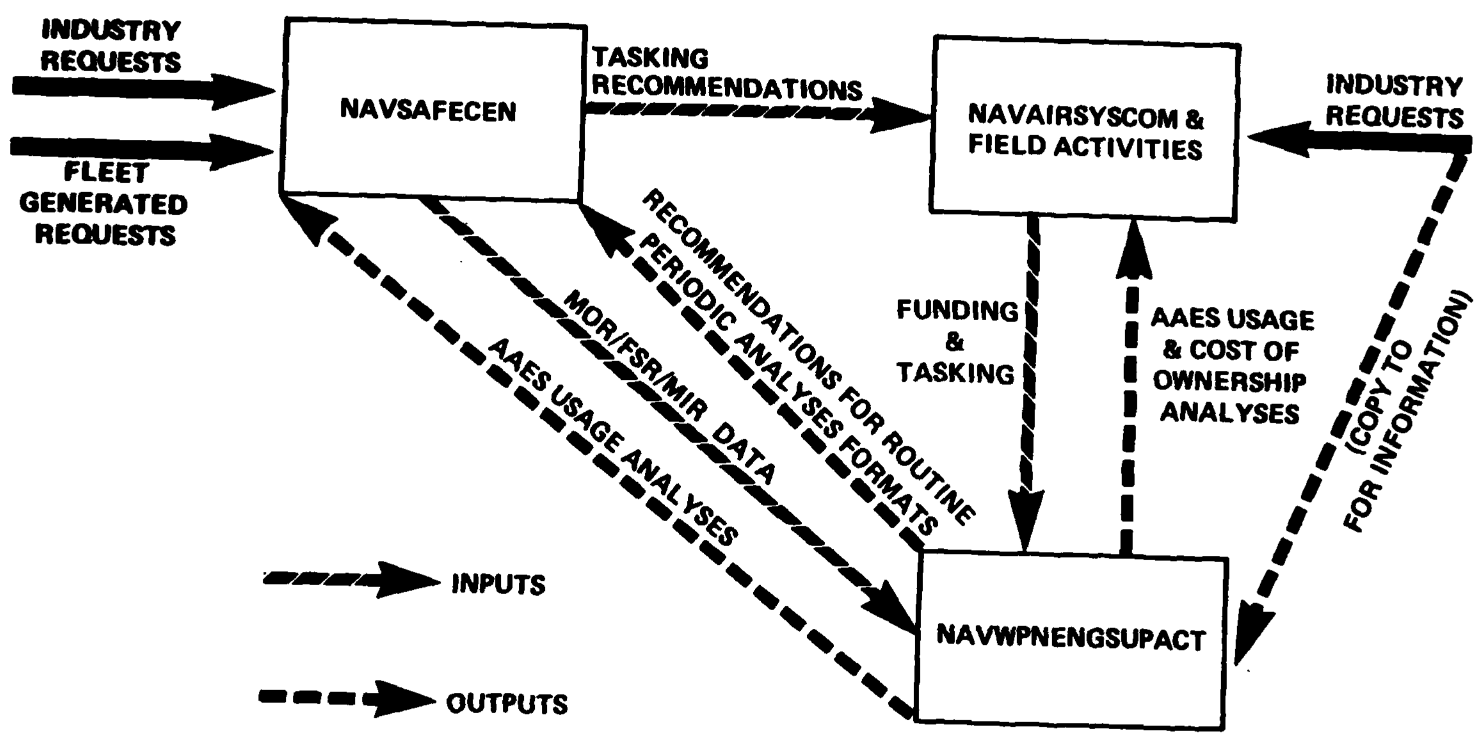


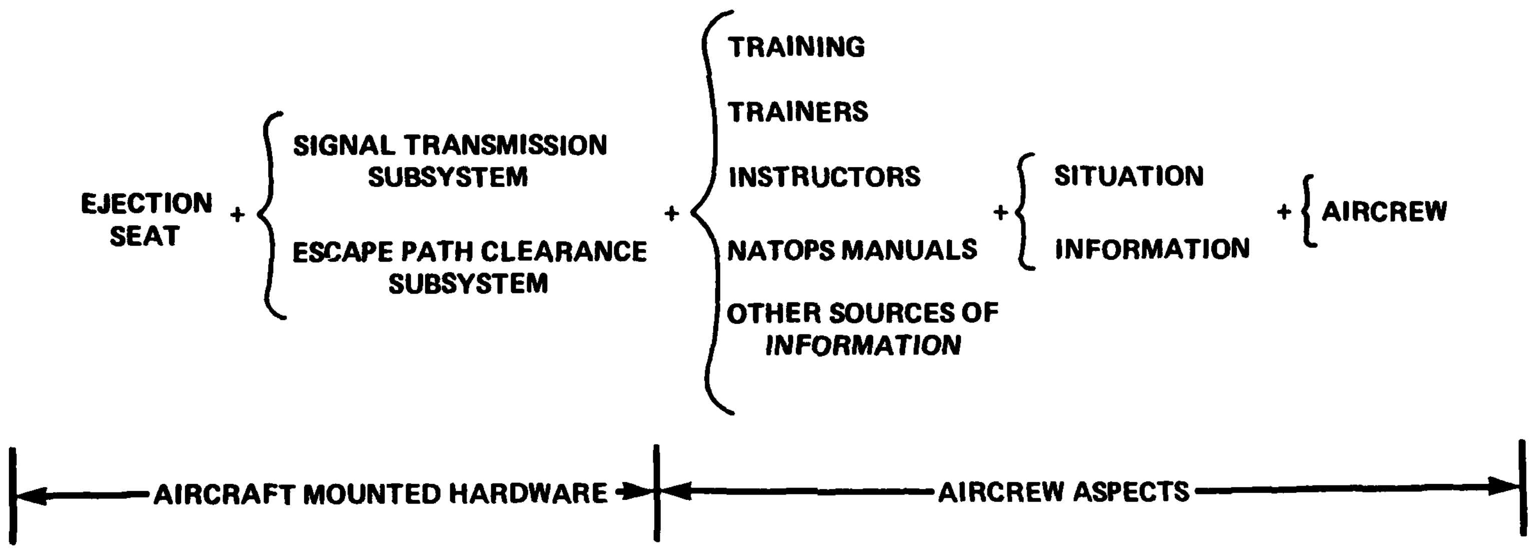
Figure 6

AIRCREW AUTOMATED ESCAPE SYSTEMS (AAES) IN-SERVICE USAGE DATA ANALYSES PROGRAM

INTERRELATIONSHIPS BETWEEN
NAVAL SAFETY CENTER, NAVAL AIR SYSTEMS COMMAND, NAVAL WEAPONS ENGINEERING SUPPORT ACTIVITY
SHOWING TYPICAL FLEET AND INDUSTRY
ANALYSES REQUEST ROUTES



COMPONENTS OF COMPLETE AIRCREW AUTOMATED ESCAPE SYSTEM



U.S. Navy Aircrew Automated Escape Systems (AAES) In-service Usage Data Analysis Program Automation Plans

Charles W. Stokes III and Frederick C. Guill

INTRODUCTION

Under tasking by the Crew Systems Division (AIR-531) of the Naval Air Systems Command, the Naval Weapons Engineering Support Activity (NAVWESA) is developing automated procedures and techniques as components of the Aircrew Automated Escape Systems (AAES) In-service Usage Data Analysis Program. Under this program NAVWESA is in the early stages of developing a system for the identification and preliminary investigation of AAES injury-producing and potentially injury-producing problems and reliability and maintainability problems. A separate paper in this collection entitled U.S. Navy Aircrew Automated Escape Systems (AAES) In-service Usage Data Analyses Program introduces the program and details its objectives.

This Program is intended to aid the Crew Systems Division and its field activities in identifying and defining AAES problems in ways assisting them in deciding how best to allocate scarce resources and in defining design, design performance, and test and evaluation requirements to assure that future AAES and ALSS design and production better melds technology and fleet needs. The Program is being conducted with the assistance of the Naval Safety Center, Norfolk.

PRESENT SYSTEM - January 1982

The present NAVWESA data system is limited in the scope of data embraced and in the facility of performing data analyses. The primary thrust of the NAVWESA efforts to date has been to gain familiarity with the various data bases available for use in meeting program objectives as well as the limitations associated with the data bases; to gain familiarity with the types of aircrew escape systems and flight and survival garments and equipments used, especially with respect to configuration variations; and to gain an appreciation of the types and range of potential needs which the program must satisfy.

Thus the primary effort has been to develop preliminary software for analyzing the primary and often most critical of the data bases providing information concerning the in-service usage of Navy AAES.

These data, furnished by the Naval Safety Center, Norfolk, are extracts from the Medical Officer's Report (MOR)/ Flight Surgeon's Report (FSR) records for the period 1 January 1969 to 31 December 1979. These 1,816 records form the present NAVWESA data base and consist of two parts: one coded and computerized, the other in printed text form and not computerized.

The computerized records consist of selected fields which were extracted from the Safety Center's MOR/FSR computer data base. Due to Privacy Act considerations, all information, especially personal data, that the Safety Center deemed inappropriate to release was deleted. A magnetic tape of these coded records was transmitted to NAVWESA accompanied by computer printouts of the narrative information associated with each MOR record.

The coded records have been entered into NAVWESA's computers in basically the same format as that of the Safety Center. (No attempt has been made to computerize the narrative information as yet.) In most cases, specially written computer programs have been used to process the coded MOR data. Processing at this time involves simple functions such as sorting, searching, printing, and computing elementary statistics. The most frequently used code translation tables have been computerized but no automatic translation process has been developed. The lack of resources has restricted computer processing to this elementary level which is supplemented by a great amount of tedious manual examination of the data.

Present concerns are focusing on the following and similar problems so as to enable AIR-531 to further enhance the capability of both present inventory AAES and future design capability to return U.S. Navy aircrew to full flight status with minimal delay following an aviation mishap:

(a) Under what conditions and why do U.S.N. aircrew not attempt escape prior to aircraft impact with the surface?
(b) Under what conditions and why do U.S.N. aircrew attempt out-of-envelope escape?
(c) What injuries do surviving ejectees sustain and what are their causes?
(d) What role, if any, does AAES design have in reducing or increasing the incidence of drowning?
(e) What effect does AAES design have upon groundcrew and facility safety?
(f) What effect does AAES design have upon increasing or decreasing maintenance workload?
(g) What design aspects of AAES experience the greatest failure rates, when are these detected, what impact have they upon crew safety, and why do they occur?

The present capabilities primarily are limited to performing detailed sorts of the data to aid AIR-531 personnel or AIR-531 laboratory personnel investigations into specific aspects of AAES and associated ALSS. Nonetheless, some aircraft flight parameter distributions have been automated. These are:

- o Airspeed (Figure 1)
- o Pitch Attitude (Figure 2)
- o Bank Attitude (Figure 3).

The system produces, upon request, a distribution for a specific seat or all seats in the data base. The extent of automation beyond these functions is limited at present to simple searches for records having a specified set of data values.

AUTOMATION PLANS - Near Term

Due to requirements for quick-response capabilities and in order to eliminate the error prone, slow manual operations, greater automation is imperative. Currently the two primary areas of automation interest are the updating and retrieval of the data base, and simulation of flight and ejection dynamics.

Using the experience gained with the present data base, new data base and record formats will be developed which may require creation of entirely new data items and coding schemes. This will be a permanent data base into which the information from the present 1,816 records will go as 11 as post-1979 FSR data and, if permitted, information from pre-1969 MOR records. Quarterly updates of the data base with reports and statistical distributions will be produced automatically. The computerized data base will also be expanded to include narrative and message text with search techniques enabling an analyst to quickly locate and examine information which now is found only by leafing through voluminous computer printouts.

Once a permanent data base has been established and all data validated, certain functions, techniques and procedures will be developed. Simulation modeling of aircraft and ejection seat dynamics is a high priority task. Using aircraft parameters, (aircraft model, speed, altitude, attitude, manuever, descent rate, etc.), escape system configuration data, ejectee weight, ejectee flight and survival garments and equipments, and other data about ejection sequences, the models will be valuable tools in assessing out-of-envelope and possibly out-of-envelope ejections, many ejection problems, as well as failures to eject.

Standard formats will be designed for reports, graphical distributions, data plots, tables, and matrices. Information requesters will be able to specify the entire data base or any subset thereof when using these basic data presentation formats to display and compare such things as survival/fatality rates and trends, injury patterns, egress/descent/landing problems, and equipment problems.

Some special problem areas will require specific formats and procedures. For example, comparative analyses of canopy methods will have automatic through-the-canopy versus jettisoned-canopy, partially-cut-canopy, and total-fragmentation-canopy reports and distributions; studies of altered states of consciousness will need displays of helmet information, head injuries and periods of unconsciousness; and vertebral injury investigations will use formats for comparing such injury patterns automatically.

AUTOMATION PLANS - Long Term

Long term objectives include: models for predicting problems in scenarios, three dimensional graphic simulations of aircraft flight and crewmember ejection; injury analysis via body or skeletal sketches; AAES/ALSS specifications and standards data base and tracking system; 3M and Unsatisfactory Report data bases; AAES/ALSS configuration data base; and AAES Test data (digital, film, image) analyses. Eventually, as the program is envisioned, it will encompass analyzing not only MOR data but also AAES configuration data (to a very small degree done at present), 3M data, UR data, NOR data, test data, and other pertinent data. The analytic effort, even at this very early stage, involves a complex interaction of engineering, medical, physiological, training, and other specialized AAES and ALSS equipment knowledge and expertise. The final system will feature automatic statistical techniques, quick production of standard displays, quarterly data base updates, and ease of use by non-computer personnel. Of course achievement of these objectives is contingent upon near-term progress.

SUMMARY OF TENTATIVE AUTOMATION TASKS

Of primary importance is the establishment of the MOR/FSR data base and automated techniques and procedures for selected types of analyses. The following is a tentative list of tasks planned for achieving that goal.

- o Document the accessibility and form (type data, media, coding schemes, etc.) of all pertinent MOR/FSR data.

- o Define data base query, search and retrieval functions.

- o Define standard output formats, displays and report such as:
  - Curve plots/bargraphs/histograms/distributions,
  - Injury and problem catalogues,
  - Injury/problem rankings by occurrence and severity, and
  - Demographic trees

- o Define statistical functions:
  - Survival/injury/problem rates,
  - Standard tests for interrelationships between data, and
  - Analyses of injury profile sketches.

- o Define data base logical structure.

- o Define data base update and maintenance procedures.

- o Select computer hardware/software configuration.

- o Design and implement system on selected computer.

- o Validate/correct MOR/FSR input data.

- o Load computer data base for the periods:
  - 1969 to 1979,
  - 1980 to present, and
  - Pre-1969, if available.

- o Conduct user (AIR-531) acceptance tests.

- o Operate and maintain the permanent MOR/FSR data base system.

In effort to analyze the dynamic interactions of flight conditions and escape system usage and performance, certain computer simulations will be developed. Planned Tasks include:

- o Survey existing escape system simulation computer models;

- o Select existing techniques or models for stand-alone usage or inclusion in NAVWESA developed models;

- o Define and implement new models which will:
  - Estimate ejection trajectory and envelope using such characteristics as seat type, aircraft model, seat location, altitiude, speed, attitude (blank and pitch), maneuver descent rate, ejected weight (or listed clothing and equippage & nude weight) and weight under parachute,
  - Evaluate escape delay factors, and
  - Graphically simulate ejection sequences.

Other data bases which will be gradually integrated into the system are:

- o Maintenance and Material Management (3M)/Unsatisfactory Report (UR)/Readiness data,
- o AAES test data,
- o Escape system configurations,
- o Aircraft operations,
- o Aircraft/AAES inventory,
- o AAES Ground/Maintenance mishap data, and
- o AAES/ALSS specifications and standards.

The tasks involved in bringing these data on-line are essentially the same as those required for the MOR/FSR data base. Also there will be the additional task of developing interfaces with pre-existing data bases.

Recent planning has been that the MOR/FSR data base and some simulation models would be operational and on-going by May of 1983. However, indications are already strong that at least three or four additional months will be needed as a consequence of recent staffing changes, delays in the MOR to FSR transition, assignment of higher priority short term tasks by AIR-531, and the uncertainty of funding and computer resource levels. All automated components of the Data Analysis Program will be brought on-line in accordance with priorities and resource limitations established by AIR-531.

Ejections Vs. Airspeed - Ejection Codes 1 & 5

Today's Date - 012982   SEAT TYPE-ALL   MOR Data Period - 1/69 to 12/79

All Seats   # of Ejections = 1337   % all Ejections = 100.000

AIRSPEED	# EJCT	CUM EJCT	% EJCT	CUM % EJCT	% ALL SEATS*
0 - 49	81	81	006.2	006.2	100.000
50 - 99	91	172	006.9	013.2	100.000
100 - 149	283	455	021.7	034.9	100.000
150 - 199	260	715	019.9	054.9	100.000
200 - 249	240	955	018.4	073.3	100.000
250 - 299	123	1078	009.4	082.7	100.000
300 - 349	93	1171	007.1	089.9	100.000
350 - 399	44	1215	003.3	093.3	100.000
400 - 449	31	1246	002.3	095.6	100.000
450 - 499	35	1281	002.6	098.3	100.000
500 - 549	10	1291	000.7	099.1	100.000
550 - 599	7	1298	000.5	099.6	100.000
600 +	4	1302	000.3	100.0	100.000
BLANK	0	1302			0.000
UNKWN	35	1337			100.000

Percentage of all ejections for all seats at specified airspeed

Ejections Vs. Airspeed - Ejection Codes 1 & 5

Today's Date - 012982   SEAT TYPE-3022   MOR Data Period - 1/69 to 12/79

Martin-Baker MK H7   # of Ejections = 348   % all Ejections = 26.028

AIRSPEED	# EJCT	CUM EJCT	% EJCT	CUM % EJCT	% ALL SEATS*
0 - 49	9	9	002.6	002.6	11.111
50 - 99	17	26	004.9	007.6	18.681
100 - 149	55	81	016.0	023.6	19.434
150 - 199	91	172	026.6	050.2	35.000
200 - 249	48	220	014.0	064.3	20.000
250 - 299	32	252	009.3	073.6	26.016
300 - 349	44	296	012.8	086.5	47.311
350 - 399	14	310	004.0	090.6	31.818
400 - 449	9	319	002.6	093.2	29.032
450 - 499	13	332	003.8	097.0	37.142
500 - 549	4	336	001.1	098.2	40.000
550 - 599	5	341	001.4	099.7	71.428
600 +	1	342	000.2	100.0	25.000
BLANK	0	342			0.000
UNKWN	6	348			17.142

Percentage of all ejections for all seats at specified airspeed

FIGURE 1

Ejections Vs. Pitch Angle - Ejection Codes 1 & 5

Today's Date - 012982 SEAT TYPE-ALL MOR Data Period - 1/69 to 12/79

All Seats # of Ejections = 1337 % all Ejections = 100.000

PITCH ANGLE	# EJCT UP	# EJCT DWN	CUM EJCT UP	CUM EJCT DWN	% EJCT UP	% EJCT DWN	% ALL SEATS* UP	% ALL SEATS* DWN
1 - 15	123	231	123	231	9.1	17.2	100.000	100.000
16 - 30	22	104	145	335	1.6	7.7	100.000	100.000
31 - 45	13	47	158	382	0.9	3.5	100.000	100.000
46 - 60	6	54	164	436	0.4	4.0	100.000	100.000
61 - 75	0	19	164	455	0.0	1.4	0.000	100.000
76 - 90	2	45	166	500	0.1	3.3	100.000	100.000
91 +	0	1	166	501	0.0	0.0	0.000	100.000
UDBLANK	140	46	306	547	10.4	3.4	100.000	100.000
LEVEL	284		1137		21.2		100.000	
NO CODE	200		1337		14.9		100.000	

Percentage of all ejections for all seats at specified pitch angle

Ejections Vs. Pitch Angle - Ejection Codes 1 & 5

Today's Date - 012982 SEAT TYPE-3022 MOR Data Period - 1/69 to 12/79

Martin-Baker MK H7 # of Ejections = 348 % all Ejections = 26.028

PITCH ANGLE	# EJCT UP	# EJCT DWN	CUM EJCT UP	CUM EJCT DWN	% EJCT UP	% EJCT DWN	% ALL SEATS* UP	% ALL SEATS* DWN
1 - 15	33	57	33	57	9.4	16.3	26.829	24.675
16 - 30	7	34	40	91	2.0	9.7	31.818	32.692
31 - 45	6	10	46	101	1.7	2.8	46.153	21.276
46 - 60	0	17	46	118	0.0	4.8	0.000	31.481
61 - 75	0	5	46	123	0.0	1.4	0.000	26.315
76 - 90	2	11	48	134	0.5	3.1	100.000	24.444
91 +	0	0	48	134	0.0	0.0	0.000	0.000
UDBLANK	37	10	85	144	10.6	2.8	26.428	21.739
LEVEL	67		296		19.2		23.591	
NO CODE	52		348		14.9		26.000	

Percentage of all ejections for all seats at specified pitch angle

FIGURE 2

Ejections Vs. Bank Angle - Ejection Codes 1 & 5

Today's Date - 012982 SEAT TYPE-ALL MOR Data Period - 1/69 to 12/79

All Seats # of Ejections = 1337 % all Ejections = 100.000

BANK ANGLE	# EJCT		CUM EJCT		% EJCT		% ALL SEATS*	
	LFT	RGT	LFT	RGT	LFT	RGT	LFT	RGT
1 - 30	129	82	129	82	9.6	6.1	100.000	100.000
31 - 60	37	30	166	112	2.7	2.2	100.000	100.000
61 - 90	27	23	193	135	2.0	1.7	100.000	100.000
91 +	20	4	213	139	1.4	0.2	100.000	100.000
LRBLANK	20	51	233	190	1.4	3.8	100.000	100.000
LEVEL	391		814		29.2		100.000	
NO CODE	523		1337		39.1		100.000	

Percentage of all ejections for all seats at specified bank angle

Ejections Vs. Bank Angle - Ejection Codes 1 & 5

Today's Date - 012982 SEAT TYPE-3022 MOR Data Period - 1/69 to 12/79

Martin-Baker MK H7 # of Ejections = 348 % all Ejections = 26.028

BANK ANGLE	# EJCT		CUM EJCT		% EJCT		% ALL SEATS*	
	LFT	RGT	LFT	RGT	LFT	RGT	LFT	RGT
1 - 30	41	24	41	24	11.7	6.8	31.782	29.268
31 - 60	6	10	47	34	1.7	2.8	16.216	33.333
61 - 90	8	5	55	39	2.2	1.4	29.629	21.739
91 +	10	1	65	40	2.8	0.2	50.000	25.000
LRBLANK	7	12	72	52	2.0	3.4	35.000	23.529
LEVEL	88		212		25.2		22.506	
NO CODE	136		348		39.0		26.003	

Percentage of all ejections for all seats at specified bank angle

FIGURE 3

ANALYTIC TECHNIQUES

A major problem confronting and, in many instances confounding, those responsible for, and potential users of, aircrew automated escape systems (AAES) is attempting to ascertain how well or how poorly a particular piece of equipment, a particular conceptual approach or technique, or a particular system is performing. Typically simple measures of a non too simple problem are created and employed such as percentage rates to measure success (eg., percentage of ejectees surviving) or to measure problems (eg., percentage of ejectees incurring major injuries, etc). These yardsticks of performance are extremely important yet, at the same time, as a consequence of their virtue of being easily understood by many people, they may become extremely dangerous since few in truth really understand them.

Frequently these performance yardsticks after being computed are plotted to display for everyone their trends, sometimes delineated carefully by imposing techniques which many of us vaguely recall as being the proper approach without recalling the proper conditions for usage of the techniques nor the caveats concerning technique use. As a consequence impressions can be generated and emotional battles fought to enhance aircrew safety; but the proposed actions in fact may be inappropriate as a consequence of the oft-forgotton limitations of percentage-type data arrays and/or of the analytic techniques and tools employed to examine these data.

An important task assigned to the Naval Weapons Engineering Support Activity, Washington, D.C., as a part of the program to analyze in-service usage data for aircrew automated escape systems (AAES) is to develop and demonstrate appropriate analytic techniques for routine, standardized repeated analyses of AAES performance which could be implemented on a routine basis and which avoid many of the perils of current approaches. As a initial step in accomplishing this part of the tasking, problems with some of the current approaches are discussed in the paper Problems With the Use of Percentages In the Analysis of AAES Data.

PROBLEMS WITH THE USE OF PERCENTAGES IN THE ANALYSIS OF AAES DATA

JOHN E. VETTER

NAVAL WEAPONS ENGINEERING SUPPORT ACTIVITY
WASHINGTON D.C.

SAFE Symposium
December 1981
Las Vegas, Neveda

PROBLEMS WITH THE USE OF PERCENTAGES IN THE ANALYSIS OF EJECTION FATALITIES

A very popular and sometimes meaningful way to present or compare data is to employ the number of events per 100 trials or the percentage of events among trials as the measure for comparison. The interpretation of a percentage is that for every 100 trials, a specific event is expected to occur with certain frequency (f). There are dangers associated with percentage data if the number of trials is small and/or vary between the comparisons.

The observed percent in a set of trials is an estimate of the expected number of events per 100 trials. Two sets of trials will not necessarily result in the same measure for the expected number of events per 100 trials (percentage). The amount of variation will depend upon the sample size, (n), i.e., how large a set of trials. The larger the sample size, the smaller the variation among sample percentages arising from repeated samples. The amount of variation as a function of sample size can be seen clearly by looking at the effect of a difference of one success. For example, if the sample size is two, the only percentage points which could be observed are 0%, 50%, or 100%. Therefore, a difference of one success will change the percentage by 50 percentage points. If the sample size is 50, then percentage points of 0%, 2%, 4%, 6% etc. can be observed. A difference of one success will vary the percentage point by only 2 units. For larger sample sizes the impact of one success becomes even less. Having recognized the problem of variation among repeated trials, it becomes imperative to include the sample size along with any numerical or graphic presentation of percentages.

COMPARISON BETWEEN TWO PERCENTAGES

Comparing two percentage points must be done with their respective sample sizes in mind. If both percentage points were based on large sample sizes, then the comparison can be made with greater confidence. If either one is small, then comparisons should not be made without adjustments for sample size differences, since comparisons might be misleading.

A point estimate of a percent is not very meaningful without some measure of the repeatibility of the estimate. An estimate should be accompanied by some interval about the estimate, together with some measure of assurance that the interval includes the true parameter. This interval is called the confidence interval and the measure of assurance is called the confidence coefficient. The confidence coefficient expresses the percentage of the samples for which the confidence interval will contain the true parameter.

The point estimate ($\hat{p}$) for a percent based upon a random sample of n trials is given by:

$$\hat{p} = f/n \tag{1}$$

and the confidence interval for this percentage is given by:

$$(\hat{p} - Z_\alpha S) < p < (\hat{p} + Z_\alpha S) \tag{2}$$

where f is the frequency of the event in the n trials, $1 - \alpha$ is the confidence coefficient, $S = [f(n - f)/n^3]^{\frac{1}{2}}$ and Z_α locates points which cut off $\alpha/2$ percent of the area on each tail of the normal distribution. As an example, if $\alpha = .10$, then $1 - \alpha = .90$ and Z_α is the point on the normal distribution which cuts off 5% in each tail. This point, $Z_{.10}$, equals 1.645 and we have a 90% confidence that the true percent, p, is encompassed within the interval $(\hat{p} - 1.645S)$ and $(\hat{p} + 1.645S)$.

One possible alternative to plotting percentage points by themselves is to include a bar which represents a confidence interval around the percentage point.

ANALYSIS OF PERCENTAGE DATA FOR DIFFERENT TIME PERIODS

An example of percentage data on ejections with their corresponding confidence intervals is presented in Table 1. The ejection data in this table is presented for each year during the period 1969 - 1979 and the ejections include all types 1, 2, 3, 5 and 6 which are all the known attempted ejections. (OPNAVINST, Definition of Types)

Table 1. Ejections of Types 1, 2, 3, 5 and 6 With the Number of Survivors, Percentage Estimate and 90% Confidence Limits for Each Year

Year	Survived	Total	$\hat{p}$	$S_{\hat{p}} = \sqrt{\hat{p}\hat{q}/n}$	90% Confidence Limits	
					LL	UL
1969	213	253	.853	.0223	.816	.890
1970	165	203	.813	.0274	.768	.858
1971	129	149	.866	.0279	.820	.912
1972	139	162	.858	.0274	.813	.903
1973	110	130	.846	.0317	.794	.898
1974	60	75	.800	.0462	.724	.876
1975	76	94	.809	.0405	.742	.876
1976	64	85	.753	.0468	.767	.830
1977	74	92	.804	.0414	.736	.872
1978	61	77	.792	.0463	.716	.868
1979	46	55	.836	.0499	.754	.918

The percentage data, $\hat{p}$, from Table 1 was plotted without regard to sample size and this plot is shown in Figure 1. One might conclude from this plot that a downward trend in survival rates existed during the observation period. However, careful review is necessary before such a conclusion be drawn.

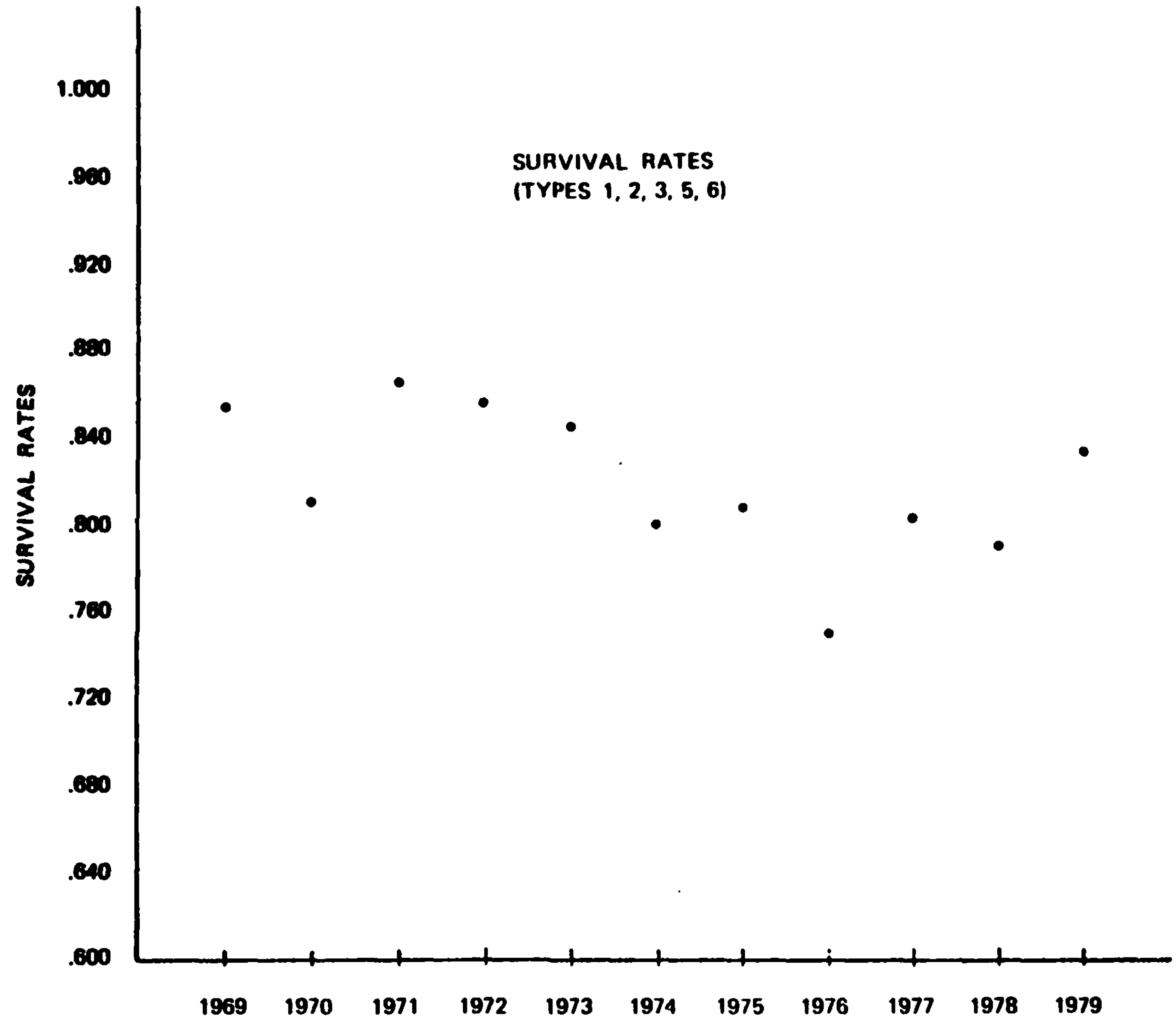


Figure 1. The Annual Survival Percentage for the AAES for the 1969 - 1979 Period

The percentage data and the confidence intervals about each percentage is presented in Figure 2. In this format it is easier to recognize the effect of sample sizes for the confidence intervals are smaller for the years 1969 - 1973 than they are for the years 1974 - 1979. Furthermore, if the overall percentage is superimposed upon the plot then the majority of the points before 1974 are above the aggregated percentage and the points after 1973 are predominantly below the aggregated value. This observation suggests that the data before 1974 actually differs in some way from the data after 1973. It was later discovered that beginning in 1974 a change was made in the definition of an ejection attempt. Figure 3 shows that about a 4% difference in the aggregate rate exists between the two periods. Within the two periods, however, no trend exists and in fact the difference between the two periods may be explained for the most part by the change in ejection definition.

Another technique, often used to show trends over time, is to fit a linear trend line through the percentage points using the method of least squares. While this technique is valid if the confidence bands around all the points are approximately equal (i.e., the variance is nearly the same), the technique is faulty when some points have larger variance than others, i.e., the larger the variance, the less information contained in the point.

In order to eliminate this problem and still provide a visual representation of trend, a weighted least squares method should be used. This is accomplished by giving each percentage point a weight usually inversely proportional to variance. Thus, a point with very large variance will get very small weight in determining the slope of the trend line. Since large variance for percentages means a small sample size, the sample size itself can be used to weight the points.

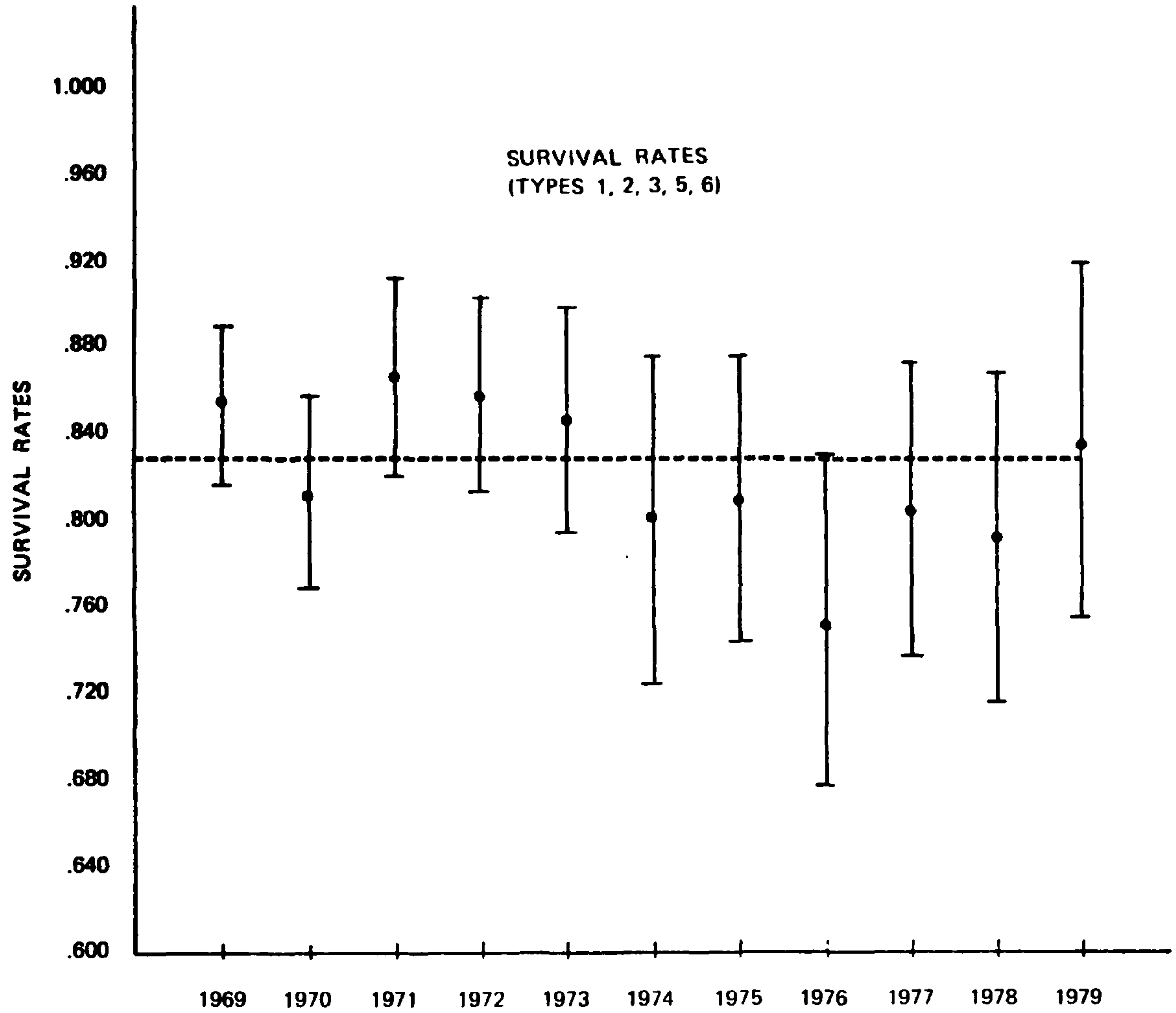


Figure 2. The Annual Survival Percentage for the AAES for the 1969 - 1979 Period and the 90% Confidence Intervals Shown as the Vertical Lines Through the Observed Points With the Aggregated or Overall Percentage Superimposed as a Dotted Line

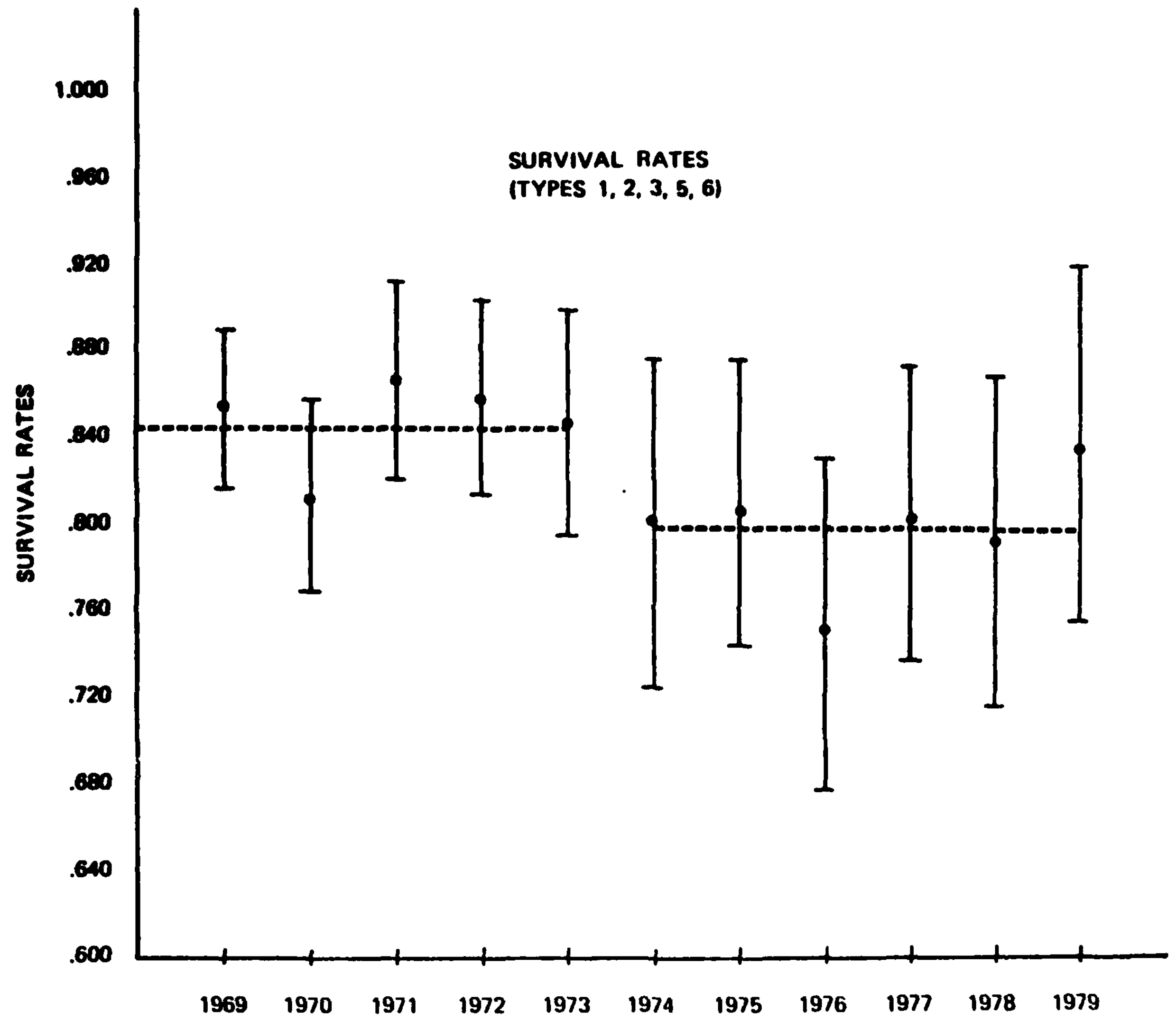


Figure 3. The Annual Survival Percentage for the AAES for the 1969 - 1979 Period and the 90% Confidence Intervals Shown as the Vertical Lines Through the Observed Points With the "Average" Percentage Superimposed as a Dotted Line for Each of the Two Periods

One very important advantage to this technique is that one very large or small percentage point, based upon only a few observations, will not pull the trend toward it and, thus, prevent a distortion of information provided by the graph. For example, examine the five percentage points presented in Table 2 and the weighted and unweighted trend lines shown in Figure 4.

Table 2. Hypothetical Data To Illustrate the Effect of Ignoring the Imbalance in Sample Sizes When Employing Percentages

Ejections	100	200	200	120	20
Survivals	86	159	170	100	10
Percentage	86.0	79.5	85.0	83.3	50.0

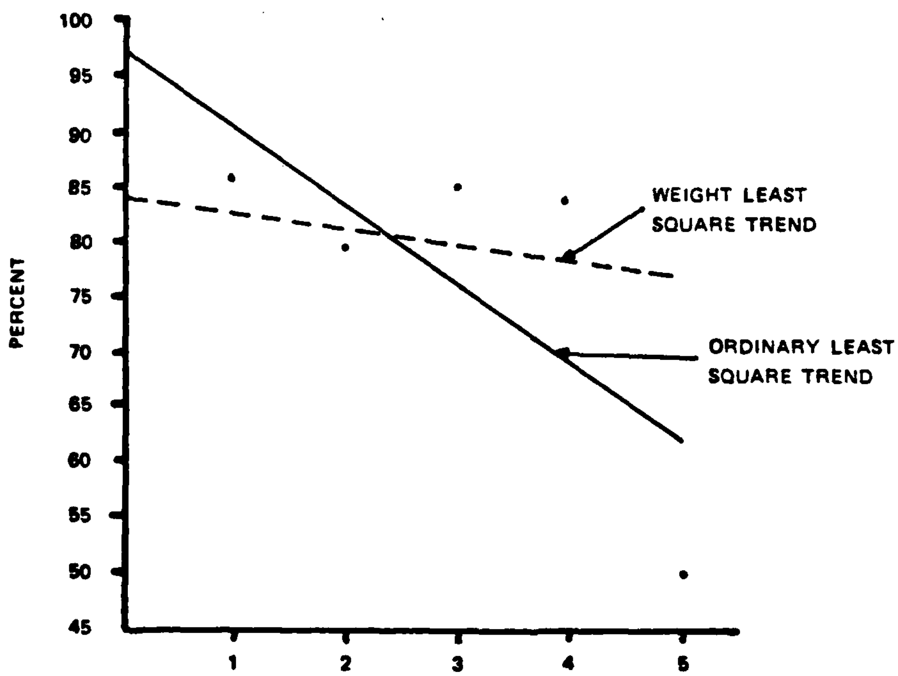


Figure 4. The Weighted and Unweighted (Ordinary) Trend Lines for the Hypothetical Data of Table 2

The difference in the weighted and unweighted regression (trend) lines is dominated by the difference in how the last point is employed in the determination. The last point (with sample size 20) has equal weight to the other points in the ordinary procedure, while it is given little weight (proportional to size) in the weighted procedure. Incorrect inferences may be made concerning trends if unweighted regression techniques are applied to situations involving major differences in sample sizes.

The alternatives in data presentation and analysis provided here indicate that percentage data compared over time must be treated carefully with respect to any imbalance in the sample sizes.

PERCENTAGE REPRESENTATIONS WITH PIE CHARTS

Pie charts are one of the most popular forms of data presentation. However, they can be misleading because of the generalizations they imply and the fact that a pie chart shows only the relative contribution among the items involved. The problems associated with percentage comparisons are similar to those discussed earlier. Specifically, any imbalance in sample size must be recognized before inferences can be drawn.

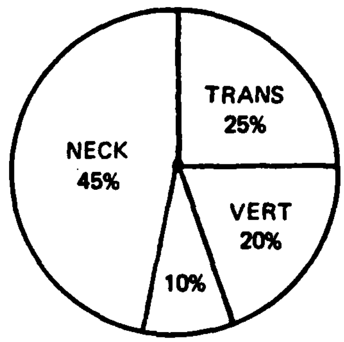
The pie chart presents an additional problem in that it can be partitioned into many divisions, but the size of any one slice affects the size of all the others. Thus, an increase in one part naturally reduces the size of one or more of the other parts. Consider the hypothetical example on the next page where the number of transection injuries in a given situation is reduced by 50% from a previous situation and all other injuries stayed the same.

Table 3. A Hypothetical Example of Two Situations Where the Number of Injuries Differ Among Types and the Affect Upon Their Pie Chart Representation

ORIGINAL SITUATION:

INJURY	NUMBER	PERCENT
NECK	90	45.0
TRANSECTION	50	25.0
VERTEBRAL	40	20.0
OTHER	20	10.0
TOTAL	200	100.0
TOTAL EJECTIONS	400	

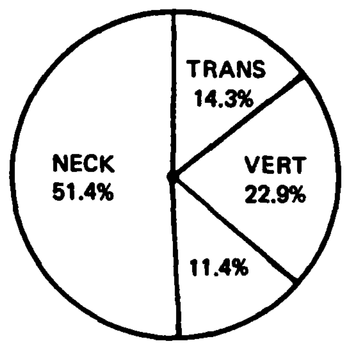
PIE CHART



NEW SITUATION:

INJURY	NUMBER	PERCENT
NECK	90	51.4
TRANSECTION	25	14.3
VERTEBRAL	40	22.9
OTHER	20	11.4
TOTAL	175	100.0
TOTAL EJECTIONS	400	

PIE CHART



The transections in the new situation account for 13.8% of all injuries, but neck injuries account for 51.7% of all injuries and not the 45.0% as before. The problem is not that a mistake has been made, but that some observers may infer from the pie chart alone that neck injuries, say, have increased. The rate of neck injury relative to other injuries has increased, but the rate of neck injury relative to ejections has not changed. Thus, great care should be taken to clarify the base for the percentage before inferences are made.

Since charts are presented to convey information and are not usually presented to mislead the observers, the sample size upon which the percentages are based should always be included somewhere on the chart. The basis upon which the percentage is calculated should also be clearly stated somewhere, perhaps in the title or chart label.

PERCENTAGE PROBLEMS WITH CATEGORICAL DATA

It is often important to partition data into multiple classifications in order to gain insight into the underlying relationships among variables and to make inferences about the events which the data represent. Here, again, an imbalance in the number of events can result in an erroneous picture, if only percentages are used. The following examples illustrate some of the problems associated with percentage data used in categorical situations.

Example 1. Hypothetical Service Experience With Environmental Variables

The following table was constructed with hypothetical data to show the effect of three variables, canopy mode, altitude at ejection and speed at ejection upon the fatality rate of ejectees. A more detailed presentation using actual data from ejection experience is presented in another paper entitled "An Analysis of the Fatality Rate

Data From 'Jettison Canopy' and 'Through Canopy' Ejections From Automated Airborne Escape Systems," and it is included in the proceedings of this symposium.

Table 4. A Hypothetical Example To Illustrate Hidden Information in the Aggregation of Data From Unbalanced Experience Data

Mode of Ejection	Jettison of Canopy				Through-The-Canopy			
Altitude at Ejection	Low		High		Low		High	
Speed at Ejection	Slow	High	Slow	High	Slow	High	Slow	High
Number of Fatalities	1	1	10	1	2	10	1	1
Number of Ejections	5	2	100	10	10	20	10	10
% of Fatalities	20%	50%	10%	10%	20%	50%	10%	10%
	29%		10%		40%		10%	
	11%				28%			

This illustration was constructed under three basic assumptions. One assumption was that speed at ejection has an effect on fatality rates at low altitude and no effect at high altitude. In Table 4 observe that an ejection at slow speed at low altitude has a 20% fatality rate, while ejection at high speed has a fatality rate of 50% which satisfies the assumption. These fatality rates are the same for both Jettison Canopy and Through-the-Canopy. A second assumption, employed in the table construction, is that ejection at different altitude has an effect on fatality rate. Again, observe in Table 4, that for ejection at slow speed, low altitude has a 20% fatality rate, while ejection at high altitude has a fatality rate of only 10%. Then ejection at high speed,

low altitude has a 50% fatality rate, while ejection at high altitude has a fatality rate of only 10%. Also the effect of altitude on ejection fatality rates is the same for both canopy modes. A third assumption in the construction of the table was that the mode of ejection does not affect ejection fatality rates, i.e., for each combination of the variables, altitude and speed, the ejection fatality rate is the same whether the mode is Jettison Canopy or Through-the-Canopy. The observations in each combinational cell were selected to represent exactly the assumed effects, but the numbers of observations in the cells were intentionally distorted to illustrate more clearly the analysis problem.

Based upon the data in Table 4, the number of ejections using the Jettison Canopy (JC) mode is 117. Of the 117 ejections, 100 occurred at high altitude and slow speed - a relatively safe risk condition. Since such a great proportion of the JC ejections occurred where the fatality rate is 10%, the overall rate for all JC ejections (11%) is fairly close to 10%. If all JC ejections occurred at high altitude and slow speed, then the overall Jettison fatality rate would be exactly 10%. Given the data in the above table as data observed from fleet service, what can be discerned? If speed and altitude are ignored, one could conclude that difference in the mode of ejection was the source for the differences in fatality rates; however, we know that was not the basis upon which the table was constructed. The problem of using unweighted percentages, which was discussed in the section on trend analysis, again applies to these data. If you observe the percentage pattern among cells within the mode of ejection, it becomes clear that there is no difference between modes. Such pattern analysis among cells requires the simultaneous weighted analysis of all the cells. If the

number of observations were balanced among the cells, then various combinations of cells can be compared without the distortion created in the above example. A revised table with balanced data, i.e., equal numbers of observations in the cells, is shown below as Table 5 where the cell percentages are the same as the original example, but based upon equal sample sizes. The effects of speed, altitude and mode of ejection are easy to establish in this balanced situation.

Table 5. The Hypothetical Example
With Equal Number of Observations in Each Cell

Mode of Ejection	Jettison of Canopy				Through-The-Canopy			
Altitude at Ejection	Low		High		Low		High	
Speed at Ejection	Slow	High	Slow	High	Slow	High	Slow	High
Number of Fatalities	20	50	10	10	20	50	10	10
Number of Ejections	100	100	100	100	100	100	100	100
% of Fatalities	20%	50%	10%	10%	20%	50%	10%	10%
	35%		10%		35%		10%	
	22.5%				22.5%			

Example 2. Hypothetical Service Experience With Design Modification

Another situation occurs frequently in hardware systems when multiple design changes have been installed in the fleet and it is desired to evaluate the effects of the modifications. In the following example Table 6 was constructed so that Modification A reduces the fatality rate by 50%, Modification B does not affect the fatality rate, and the cell observations are unbalanced.

Table 6. A Hypothetical Example of Incident Data To Illustrate the Information That Can Be Hidden in Unbalanced Experience Data

	System With Modification A	System Without Modification A	Total
System With Modification B	10% $\frac{10}{100}$	20% $\frac{1}{5}$	10.5% $\frac{11}{105}$
System Without Modification B	10% $\frac{1}{10}$	20% $\frac{20}{100}$	19% $\frac{21}{110}$
Total	10% $\frac{11}{110}$	20% $\frac{21}{105}$	15% $\frac{32}{215}$

The denominators of the fractions in the cells represent the total number of events observed, while the numerator represents the subset of total events which encompassed a fatality.

In this example, if the marginal totals are used to evaluate the effect of each modification, i.e., not recognizing the imbalance in the number of observations, one could draw the erroneous conclusion that Modification B has an effect in reducing the fatality rate from 19% to 10.5%. This potential difficulty arises only because of the unequal number of observations in cells and it disappears when the cell sample sizes are equal. In Table 7 the cells have equal numbers of observations and the difference due to Modification A and lack of a difference due to Modification B are clearly visible.

Table 7. The Preceding Hypothetical Example With Equal Number of Observations in Each Cell

	System With Modification A	System Without Modification A	Total
System With Modification B	10% $\frac{10}{100}$	20% $\frac{20}{100}$	15% $\frac{30}{200}$
System Without Modification B	10% $\frac{10}{100}$	20% $\frac{20}{100}$	15% $\frac{30}{200}$
Total	10% $\frac{20}{200}$	20% $\frac{40}{200}$	15% $\frac{60}{400}$

It is not possible to control the sample size in the cells when you are relying upon service experience to generate the data to be analyzed. Therefore, the analysis must recognize all imbalances.

The above examples are used to illustrate the care that must be taken in analyzing unbalanced data and they emphasize the need to simultaneously analyze the cell data, rather than just compare row or column totals. There are analytical procedures that are applicable to these enumeration data situations where differences in the number of events (or trials) are recognized. The applicable techniques are referred to as multidimensional cross-classified categorical data techniques. An example of these techniques, using actual data on neck injuries sustained during aircraft ejection is presented in the following section.

An Analysis of Spreader Gun and Powered Inertial Reel Upon Neck Injury Installed in A4/A7 Aircraft

The data for this analysis is taken from the AAES data presented at the October 1981 Symposium (AAES Data Analysis Program, Volume II, page 194). The data is reproduced here for convenience. The data, presented in Table 8, is in a slightly different form from the original.

Table 8. The Number of Neck Injuries, Ejections and Their Ratios for Various Combinations of With and Without Spreader Gun and Powered Inertial Reel in the A4 Aircraft

	Spreader Gun (SG)	No Spreader Gun
Powered Inertial Reel (PIR)	1/7 (14%)	1/102 (1%)
No PIR	8/67 (12%)	1/11 (9%)

The numerators represent the number of neck injuries and the denominators represent the number of ejections for the given category. This table is similar in form to the hypothetical example presented in the previous section. The problem with making comparisons is that there are too few ejections with both SG and PIR and too few observations with neither SG or PIR. Incorrect conclusions could be made if the percentages alone are used to draw inferences about the effects of either SG or PIR.

In order to supplement this data, the A7 aircraft with no spreader gun and no powered initial reel was included in the analysis. The revised table is presented on the next page as Table 9.

Table 9. The Number of Neck Injuries, Ejections and Their Ratios for Various Combinations of With and Without Spreader Gun and Powered Inertial Reel in the A4 and A7 Aircrafts

	Spreader Gun (SG)	No Spreader Gun
Powered Inertial Reel (PIR)	1/7 (14%)	1/102 (1%)
No PIR	8/67 (12%)	22/125 (18%)

This table is an improvement over the previous one and allows for some comparisons to be made under the assumption of equal risk exposure and no A4/A7 difference. The first cell (SG and PIR) is still very small and therefore direct inference from the percentages should not be made. The effects of the modifications can be measured, however, since the spreader gun can be compared to not having the spreader gun and at the same time not having a powered inertial reel. The effect of the powered inertial reel is not mixed with (confounding) the effect of the spreader gun on neck injury. Similarly, the PIR can be compared to not having the PIR when no spreader gun is present. What cannot be determined from this data is whether or not the two systems have an interactive effect. That is, does having both systems reduce neck injury or do they work in opposite directions.

Fortunately, statistical techniques are available which consider the imbalance in the data and allow for inferences to be made. One such technique is called "Log-Linear Model Analysis." This falls under the general heading of Multivariate Cross-Classification Analysis. Appendix A contains the details of this analysis for those who are interested. The results of the analysis, assuming the same risk exposure and no A4/A7 difference, indicate the following:

- The data do not indicate that the spreader gun has an effect on the incidence of neck injury.
- The incidence of neck injury is lower when the powered inertial reel is used.
- The effect of having both systems together cannot be satisfactorily determined.

The estimates of the expected neck injury percentages resulting from the multivariate analysis are given in Table 10. (See Appendix A)

Table 10. The Expected Percentage of Neck Injuries for Ejection Seats With Spreader Gun (SG) and/or Powered Inertial Reel (PIR) Modifications Based Upon the Experience Data Given in Table 9

	SG	No SG
PIR	2.7%	2.7%
No PIR	16.0%	16.0%

SUMMARY

Data may be collected, examined and displayed in a variety of forms. Percentage data like any other data can be used in a variety of data forms. One common problem in the use of percentage data is that the percentage points themselves do not indicate any imbalance in the data. This imbalance is represented in unequal sample sizes upon which the percentages are based. Since inferences are to be drawn and decisions, often important ones, are to be made from percentage data, great care must be taken to account for the imbalances before any inferences are made. Many simple tools exist to help account for imbalances and new statistical methods developed within the last ten years are now available.

So, the next time you hear that "Three out of four doctors recommend Anacin," don't swallow it or your headaches will be bigger than you think.

APPENDIX A

MULTIVARIATE CROSS-CLASSIFICATION ANALYSIS

The program ECTA - Everyman's Contingency Table Analysis was used to generate a log-linear model. The program was run several times to determine the model which best fits the data. The Likelihood ratio chi-square calculated was used to help select the best model.

The log-linear model selected can be described as

$$L_{ijk} = \mu + \mu_i^{A} + \mu_j^{B} + \mu_k^{C} + \mu_{ik}^{AC} + \mu_{jk}^{BC}$$

where L_{ijk} is the log of the expected cell frequency for cell (i, j, k) and the μ-effects are functions of the log odds (or probabilities) of falling in a particular category, i.e., μ_{ik}^{AC} is the log odds of falling in category i of variable A and category k of variable C.

Since one can choose injury as the dependent variable, an alternative representation of the log-linear model called a "Logit Model" was employed in the analysis. This model calculates the log of the odds of falling in one category of the dependent variable as a linear function of the log odds of the other variables which are related or associated with the dependent variable.

Significance tests were performed on all model effects. While the information contained in the logit model is the same as the log-linear model, the former representation seems to better define the underlying variable relationships.

The variables, categories, and their meanings are shown on the next page.

Variable	Category	Meaning
A.	1. 2.	No injury Injury
B.	1. 2.	Spreader gun (SG) No spreader gun (No SG)
C.	1. 2.	Power inertial reel (PIR) No power inertial reel (No PIR)

The Cell frequencies are as follows:

ABC	=	Frequency
111	=	6
211	=	1
121	=	101
221	=	1
112	=	59
212	=	8
122	=	103
222	=	22

C	A	B	
		SG (1)	No SG (2)
PIR (1)	No Injury(1)	6	101
	Injury (2)	1	1
No PIR (2)	No Injury(1)	59	103
	Injury (2)	8	22

```
THE FOLLOWING NUMBERS WERE READ FROM A CONTROL CARD
 4
                       NOTE

   THE FOLLOWING RUN IDENTIFIES 3 VARIABLES EACH WITH 2 LEVELS

           A  INJURY
          B  SPREADER GUN
          C  POWER INERTIA REEL

THE FOLLOWING NUMBERS WERE READ FROM A CONTROL CARD
 1 2 2 2
THE DIMENSIONS HAVE BEEN SET
THE FOLLOWING NUMBERS WERE READ FROM A CONTROL CARD
 2
INPUT DATA READ
    6.00    1.00  101.00    1.00   59.00    8.00  103.00   22.00
THE FOLLOWING NUMBERS WERE READ FROM A CONTROL CARD
 6
OBSERVATIONS INCREASED BY       0.50000
THE FOLLOWING NUMBERS WERE READ FROM A CONTROL CARD
 3 0 0 1 0 0 1 1 2 0 1 3 0 2 3
MARGINS FIT UNDER THE MODEL
  1  3
  2  3
AFTER ITERATION    2 THE LARGEST DEVIATION IS     0.00035
PEARSON       9.39, AND LIKELIHOOD RATIO      5.17 CHI-SQUARES
     2 DEGREES OF FREEDOM
P-VALUE FOR LIKELIHOOD RATIO CHI-SQUARE IS 0.075
THE ORIGINAL TABLE, WITH THE FITTED VALUES SHOWN BENEATH IN EACH CELL
   1ST LEVEL OF VAR  3,
                     LEVELS OF VAR  2
VAR  1           1          2
   1          6.50     101.50 I      108.00
              7.78     100.22 I      108.00
                              I
   2          1.50       1.50 I        3.00
              0.22       2.78 I        3.00
      ----------------------------------
              8.00     103.00 I      111.00
              8.00     103.00 I      111.00

   2ND LEVEL OF VAR  3,
                     LEVELS OF VAR  2
VAR  1           1          2
   1         59.50     103.50 I      163.00
             57.13     105.87 I      163.00
                              I
   2          8.50      22.50 I       31.00
             10.87      20.13 I       31.00
      ----------------------------------
             68.00     126.00 I      194.00
             68.00     126.00 I      194.00

MARGINAL TABLE
                     LEVELS OF VAR  1
VAR  3           1          2
   1        108.00       3.00 I      111.00
   2        163.00      31.00 I      194.00
      ----------------------------------
            271.00      34.00 I      305.00

MARGINAL TABLE
                     LEVELS OF VAR  2
VAR  3           1          2
   1          8.00     103.00 I      111.00
   2         68.00     126.00 I      194.20
      ----------------------------------
             76.00     229.00 I      305.00

THE ESTIMATED LAMBDA EFFECTS, THEIR STANDARD ERRORS, AND THE STANDARDIZE
D VALUES
VARIABLES OF ONLY TWO LEVELS WHERE THE SINGLE EFFECT SHOWN IS THE DIFFER
ENCE OF THE FIRST LEVEL, AND THE AVERAGE EFFECT
  1  2  3
                            EFFECT   STD ERR  STDZD VAL
GRAND MEAN EFFECT            2.531
EFFECT FOR VARIABLES
  1                          1.311     0.288     4.559
  2                         -0.793     0.288    -2.758
  3                         -0.993     0.288    -3.453
  1  3                       0.481     0.288     1.673
  2  3                      -0.485     0.288    -1.685

THE FOLLOWING NUMBERS WERE READ FROM A CONTROL CARD
 0
RUN COMPLETE     79 UNITS OF THE X DATA STORAGE ARRAY USED, OUT OF   400
0
READY
```

The model that was accepted with $LRX^2 = 5.17$ with 2.d.f. is:

$$(AC)(BC) = (A \times B | C)$$

This model states that:

- Injury (A) is independent of spreader gun (B).
- Injury is not independent of power inertial reel (C). There are fewer injuries when PIR is used.
- Spreader gun and power inertial reel have an effect upon cell frequencies but not upon injuries.
- The effect of having both SG & PIR on injury cannot be estimated from the data. Thus, there is no (ABC) term in the model.

This model in logit form is:

$$\phi^{A}_{jk} = L_{1jk} - L_{2jk}$$

where

$$L_{ijk} = \mu + \mu^{A}_{i} + \mu^{B}_{j} + \mu^{C}_{k} + \mu^{AC}_{ik} + \mu^{BC}_{jk}$$

$$\begin{aligned}
\phi^{A}_{jk} &= \mu + \mu^{A}_{1} + \mu^{B}_{j} + \mu^{C}_{k} + \mu^{AC}_{1k} + \mu^{BC}_{jk} \\
&\quad - (\mu + \mu^{A}_{2} + \mu^{B}_{j} + \mu^{C}_{k} + \mu^{AC}_{2k} + \mu^{BC}_{jk} \\
&= (\mu^{A}_{1} - \mu^{A}_{2}) + (\mu^{AC}_{1k} - \mu^{AC}_{2k}) \\
&= 2\mu^{A}_{1} + 2\mu^{AC}_{1k} \\
&= \beta^{A} + \beta^{AC}
\end{aligned}$$

Thus, the above model states that to predict the level of injury, only the overall mean between injury and no injury and the presence or non-presence of the power initial reel is required.

The analysis of the data using the log-linear model yields the following estimates of the various effects:

$$\mu_1^A = +1.311 \qquad \mu_2^A = -1.311$$

$$\mu_1^B = -.793 \qquad \mu_2^B = +.793$$

$$\mu_1^C = -0.993 \qquad \mu_2^C = +0.993$$

$$\mu_{11}^{AC} = +.481 \qquad \mu_{21}^{AC} = -.481$$

$$\mu_{12}^{AC} = -.481 \qquad \mu_{22}^{AC} = +.481$$

$$\mu_{11}^{BC} = -.485 \qquad \mu_{21}^{BC} = +.485$$

$$\mu_{12}^{BC} = +.485 \qquad \mu_{22}^{BC} = -.485$$

$$\phi_{11}^A = 2.622 + .962 = 3.584$$

$$\phi_{12}^A = 2.622 + -.962 = 1.660$$

$$\phi_{21}^A = 3,584$$

$$\phi_{22}^A = 1.660$$

To convert the logit to expected cell percentages of injury:

Anti ln (3.584) = 36.01732 = no neck injuries/neck injuries

Percent of injuries = neck injuries/(neck injuries + no neck injuries)

$= (1 + 36.01732)^{-1} = 0.02712$

Anti ln (1.660) = 5.25931

Percent of injuries $= (1 + 5.25931)^{-1} = 0.15976$

INTERPRETATION OF AAES STATISTICAL ANALYSIS

February 1982

John E. Vetter

Naval Weapons Engineering Support Activity
Washington, D.C.

FAILSAFE Meeting
February 1982
Naval Regional Medical Center
Corpus Christi, Texas

STATISTICAL ANALYSIS OF AAES DATA

INTRODUCTION

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2. Environmental

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INTRODUCTION

The Naval Weapons Engineering Support Activity (NAVWESA) has been involved in creating a database of information concerning U.S. Navy aircraft ejection incidents. The first question which should be asked is why we are collecting data and to what purpose are we maintaining hundreds of thousands of individual pieces of information. There may be many different specific answers, however, one general answer will suffice, and that is to make inferences; inferences concerning aircrew automated escape systems (AAES) and aircrew life support systems (ALSS) used by U.S. Navy personnel.

These inferences, if carefully made, will aid in the correction of problems being experienced, and in the determination of specification requirements governing AAES and ALSS design characteristics, performance, test and evaluation, production, quality assurance, manuals and training. Inferences are used by the Crew Systems Division, Naval Air Systems Command, in allocating its scarce resources to enhance aircrew safety and effectiveness.

The purpose of statistical analyses is to take a large set (sample) of data and reduce the individual elements of information to a few meaningful measures from which an investigator may make inferences con-

cerning the entire body of information. Thus, statistical analysis encompasses two major aspects: techniques of data analysis and inferences. These aspects are closely related and the inferences, either of estimation or tests of hypothesis, are dependent upon the methods of analysis.

Statistical inference is of extreme importance and proper statistical methods are imperative. Observing that one escape system has a much higher fatality rate than others, we might be tempted to infer that it has a faulty design, or perhaps that it is not as well suited for the actual escape conditions in which it is being used. Similarly, observing the presence of a ballistic spreader gun in an escape system in which the ejecting aircrew are reported incurring abnormally frequent neck injuries, we might tend to infer that the spreader gun has a faulty design, or that its use is inherently dangerous. As shown later, however, making valid inferences requires great care and the consideration of all factors which might affect the observed data.

Statistical techniques, in general, have the great advantage that they can extract the maximum amount of information contained in a set of data. However, no statistical technique or procedure can compensate for poor or bad data. Therefore, all data should be

checked for reliability and accuracy in reporting and transcription prior to the application of statistical techniques. In any statistical analysis the basic recorded data is assumed to be correct, i.e, the analytical techniques cannot correct for inaccuracies. However, missing data, incomplete data of certain types, or censored data can be handled by appropriate analytical techniques if the absence or the incompleteness of the data is independent of the questions under study.

AIRCREW AUTOMATED ESCAPE SYSTEMS (AAES) DATA BASE

The Naval Weapons Engineering Support Activity (NAVWESA) has received from the Naval Safety Center, Norfolk, a compilation of data on ejection incidents which cover the period from 1 Jan 1969 through 31 Dec 1979. This data file contains information which can be assigned to one of the following types:

1. Physiological

   - Injury Classification
   - Body Part Injured
   - Severity of Injury
   - Autopsy, if any
   - Anthropometric Data
   - Exposure, Shock

2. <u>Environmental</u>

- Aircraft Speed
- Aircraft Altitude
- Aircraft Attitude
- Aircraft Rate of Descent
- Terrain Over Which Ejection Occurred

3. <u>Hardware/Design</u>

- Aircraft, Type and Model
- Ejection Seat, Type and Model, Mode of Ejection
- Malfunctions of Hardware (Escape, Parachute)
- Types of ALSS Equipments Worn or Used
- Rescue Vehicle

4. <u>Other Information</u>

- Types of Problems Experienced
- Tactical Data (Mission, Occupants, Location in Aircraft, etc.)
- Medical Data (Days in Hospital, Days Grounded, etc.)
- Ejectee's History (Sleep, Flights, Hours Flown, etc.)

It is the complex interactions among these types of data elements which hold the answers to the causes and results of the incidents. The investigator is looking for similarities among events in order to build a body of knowledge about the effects (symptoms) and then to establish the causal factors, taking into consider-

ation full knowledge of the hardware design, environmental conditions, ejectee's physical condition and their interactions.

DATA CHARACTERISTICS

The AAES data base contains two different forms of data whose characteristics are discussed below and for which the analytical procedures differ. The two forms of data are:

* Measurement Data
* Categorical Data

Measurement data are data which are measured by some continuous scale and differences among observations can be measured by the same standard. Measurement data, then, are those which can be measured in time, distance, weight or volume. Categorical data are data which can be assigned to one of several classes where the relative differences between classes cannot always be established by standard measures.

Examples of these two forms of data are:

* Measurement (data recorded from measurements)

  examples:

  - speed
  - altitude
  - days in hospital
  - blood pressure
  - etc.

* Categorical (data recorded by classification)

  examples:

- fatality, injured, uninjured
- ejected, not ejected
- parachute opened, did not open
- cleared aircraft, did not clear
- etc.

METHODS OF ANALYSIS

The method of analysis will differ depending upon the form of the data. Statistical procedures for measurement data are the most commonly used and are given in most textbooks for single and multivariate situations. Statistical procedures for categorical data are less common and only recently have multivariate procedures evolved.

When several factors are involved, as in the AAES data, the analyses of measurement data employs common multivariate techniques such as analysis of variance, regression, discriminant analysis, factor analysis, etc. to measure differences, associations and interactions among the contributing factors.

The analysis of categorical data involving several factors employs discrete multivariate analyses to measure differences, associations and interactions among contributing factors. These discrete multivariate techniques are relatively new and are not as well known or as widely used as the techniques for measurement data.

Multivariate categorical data is usually presented in the form of cross-classified tables of counts, com-

monly referred to as contingency tables. In the analysis of contingency tables, the units of a sample are cross-classified according to each of several categorical variables. A categorical variable takes on values which serve merely as codes or names for the categories. Hence, categorical data is not "measurable" in the sense that no meaningful numerical measurement of distance or difference between the categories is available.

When several categorical variables are viewed simultaneously, they form a multidimensional contingency table with each variable corresponding to one dimension of the table. Until recent years, the statistical and computational techniques available for the analysis of cross-classified data were quite limited, and most researchers handled multidimensional cross-classifications by analyzing various two dimensional (marginal) tables; that is, by examining the categorical variables two at a time. Although such an approach often gives great insight about the relationship among variables, it

* confuses the marginal relationship between a pair of categorical variables with the relationship when other variables are present,

* does not allow for the simultaneous examination of these pairwise relationships, and
* ignores the possibility of three-factor and higher-order interactions among the variables. A three-factor interaction among the variables, say, injury, mode and altitude, exists if the relationship or association of injury with mode is different at different levels of altitude.

Two such categorical techniques, which are currently being used to analyze AAES multivariate contingency tables, are Log-Linear and Logit Analysis.

Log Linear analysis is based on a statistic called the "Odds Ratio." This statistic estimates the odds of falling into a particular cell as a function of the variables in the model. For example, one odds ratio might be the odds of surviving as a linear function of canopy mode, altitude at time of ejection and degree of pitch and bank of the aircraft at time of ejection, and any interaction effects which might be determined. Logarithms are taken in order to produce a linear model, rather than a multiplicative model. This procedure is then analogous to ordinary regression in the continuous case. The general log-linear model does not distinguish between independent and dependent variables, but treats all as dependent (response) variables whose

mutual associations are explored. The dependent variable, or variable we are trying to predict, is the particular expected cell frequency of the variables which are measured.

Logit analysis is an extension of log-linear models whereby one of the variables, say injury, is chosen as the dependent variable. A weighted linear regression of the logarithm of the odds of each variable and its higher order interactions is performed.

It is important to note that if measurement data is available, it is much more desirable than categorical data. One reason is that measurement data contains more information. Furthermore, it can always be converted to the categorical form for analyses, while categorical data cannot be converted to measurement form. In addition, many of the statistical tests for measurement data are more powerful than their counterpart for discrete data. With this in mind and in order to obtain the best information available, if there is a choice to categorize or record a measurement for an observation and that measurement can be standardized to assure repetitive and accurate results, then measurements should almost always be used.

ASSOCIATION VERSUS CAUSATION

Association is when factors change or vary together, regardless of the cause of the covariation.

An objective analysis of the association between two variables must, to a great extent, be based upon statistical methods. By statistical analysis a mathematical description of the relationship between the variables is obtained and a measure of the uncertainty of the relationship. Regression analysis is used to determine the association between two (or more) variables in situations where one (or more) of the variables is a nonrandom variable, the values of which are predetermined. Correlation analysis deals with the problem where both (many) variables are random variates. Association does not imply causation. Covariation among variables does not mean that changes in one variable causes the other to change.

Causation is when the change in one factor causes a change in another. Causation usually implies a physical or functional relationship among factors. Statistical analysis can measure covariation, but cannot determine causation. Sound experiments with proper controls, based upon a physical or functional relationship using

statistical methods of analysis, can sometimes establish cause and effect relationships. Analysis of "in-service" data may show associations among variables, but such analysis cannot by itself establish causation. Thus, statistical analysis by establishing relationships serves to aid the overall analysis efforts which include fault tree, failure mode and effects, and design analyses.

Consider the following situation where we have three factors involved in ejection seat data:

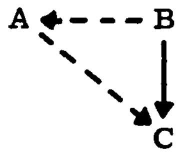
A. Ejection Seat Type

B. Aircraft Mission Type

C. Fatality Rate

If fatality rates are higher when the mission type is more severe, one can possibly conclude that the type of mission is causally related to the fatality rate. If by chance the seat used performed such that the seat (A) was highly correlated with mission type (B), then (A) and (C) would be spuriously related. That is if (B) is ignored, one might conclude that the seat is causally related to fatality rate, when in fact no fatality resulted from seat performance or lack thereof.

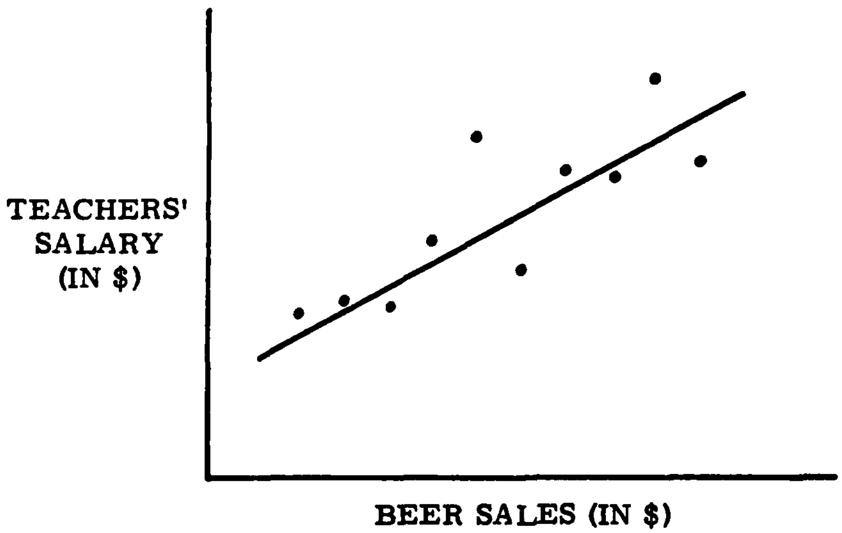
Schematically



Schematic Diagram of Association and
Causation Among Three Factors

where the dotted arrows indicate correlation and the solid arrow indicates causation.

A classic example is teachers salaries and beer sales (in dollars) observed over a ten year period.



A Classical Example of Spurious Association
Between Teachers' Salary and Beer Sales

Beer sales is highly correlated with teachers salaries, but would anyone suggest that the corresponding increase in beer sales is due to celebrating

teachers? Both beer sales and teachers salaries are highly correlated with level of business activity. As the level of business activity goes up, salaries and sales rise. Both are causally related to business activity, neither is causally related to the other.

PROBLEMS IN MULTIVARIATE ANALYSES

As discussed earlier, incorrect inferences may be drawn concerning the association between two factors, if other factors are present, but ignored.

The following illustrative example uses three types of factors present in the data base. Canopy mode is a hardware design factor. Altitude and speed at time of ejection are environmental variables and fatality rate is a physiological variable. If speed and altitude are initially ignored, suppose the following data is observed.

A Hypothetical Example of Two Factor Classification With Fatality Rates for Each Class

Hardware Design	Jettison of Canopy	Through-The-Canopy
Number of Fatalities	13	14
Number of Ejections	117	50
Physiological (Fatality Rates)	11%	28%

Through the canopy ejections have a 2.5 times higher fatality rate than jettison canopy ejections. One cannot however, conclude a causal relationship between fatality rate and canopy mode of ejection. The partitioning of the data within mode of ejection by speed and altitude illustrates the effect of these additional factors.

A Hypothetical Example of Multiple Classifications
With Unequal Observations

Mode of Ejection	Jettison of Canopy				Through-The-Canopy			
Altitude at Ejection	Low		High		Low		High	
Speed at Ejection	Slow	High	Slow	High	Slow	High	Slow	High
Number of Fatalities	1	1	10	1	2	10	1	1
Number of Ejections	5	2	100	10	10	20	10	10
% of Fatalities	20%	50%	10%	10%	20%	50%	10%	10%
	29%		10%		40%		10%	
	11%				28%			

When speed and altitude are fixed, the fatality rates for Jettison Canopy and Through-the-Canopy are observed to be the same. For example, at low altitude and slow speed, Jettison Canopy and Through-the-Canopy

both have 20 percent fatality rates. For low altitude and high speed, Jettison Canopy and Through-the-Canopy both have 50 percent fatality rates. In each case, Jettison Canopy and Through-the-Canopy are identical with respect to their fatality rate, however, if speed and altitude are ignored, we observe a much greater fatality rate for Through-the-Canopy. This anomaly is due to the imbalance in the number of ejections observed at high altitude and slow speed. A greater proportion (100/117) of the Jettison Canopy ejections in this hypothetical example occur when relatively safe environmental conditions prevail.

The statistical techniques mentioned earlier can account for imbalances for any variables included in the analysis. It can show the relationships and interactions of factors, assuming "all other things are equal." This assumption would imply, for instance, that there is no imbalance in, say, weather conditions.

The statistical techniques have the effect of balancing the data. The results of balancing the data can be seen when we observe 100 ejections in each category of speed and altitude for both Jettison Canopy and Through-the-Canopy. The overall fatality rate is then seen to be 22.5 percent for each.

The Hypothetical Example With Equal Number of Observations in Each Cell

Mode of Ejection	Jettison of Canopy				Through-The-Canopy			
Altitude at Ejection	Low		High		Low		High	
Speed at Ejection	Slow	High	Slow	High	Slow	High	Slow	High
Number of Fatalities	20	50	10	10	20	50	10	10
Number of Ejections	100	100	100	100	100	100	100	100
% of Fatalities	20%	50%	10%	10%	20%	50%	10%	10%
	35%		10%		35%		10%	
	22.5%				22.5%			

Another example of discrete multivariate analysis is presented using the following hypothetical data.

A Hypothetical Example of Neck Injuries for Various Combinations of With and Without a Spreader Gun and Powered Inertial Reel

		With Spreader Gun	Without Spreader Gun	Total
With Powered Inertial Reel (PIR)	Neck Injuries Ejections %	10 100 10.0%	1 5 20.0%	11 105 10.5
Without Powered Inertial Reel	Neck Injuries Ejections %	1 10 10.0%	20 100 20.0%	21 110 19.0%
Total	Neck Injuries Ejections %	11 110 10.0%	21 105 20.0%	32 215 14.9%

At first look, it would seem that the Powered Inertial Reel (PIR) has an effect on neck injury rates,

since the injury rate is almost twice as high without the PIR. Similarly, ejections with a spreader gun in this hypothetical example have lower neck injury rates. A closer examination of the table will show, however, that when the spreader gun is present, a comparison of injury rates with and without the powered inertial reel exhibit no difference in rates. Similarly, when the spreader gun is not present, a comparison of injury rates with PIR and without yields no difference in rates. Why, then, is the overall rate without PIR greater? This phenomenon can be explained as before by the imbalance in the number of ejections. Among the ejections with PIR there were 100 that had the spreader gun and five that did not. Thus, the overall rate for the PIR is dominated by the rate with the spreader gun. When the PIR is not present, there are 10 ejections with the S.G. and 100 without the S.G. So, the overall rate without PIR is dominated by the rate without the spreader gun.

The neck injury rate in this hypothetical population is 10 percent for ejections with the spreader gun and 20 percent without the spreader gun, regardless of whether or not the PIR is present. Therefore, if all other factors are equal, the spreader gun has the effect of lowering the neck injury rate, while the

PIR has no effect on reducing injuries. This can be more easily seen if each category had the same number of ejections. The following table, with ejections balanced with respect to the factors shows clearly the stated effects.

A Hypothetical Example of Neck Injuries for Various Combinations of With and Without a Spreader Gun and Powered Inertial Reel

		With Spreader Gun	Without Spreader Gun	Total
With Powered Inertial Reel (PIR)	Neck Injuries Ejections %	10 100 10.0%	20 100 20.0%	30 200 15%
Without Powered Inertial Reel	Neck Injuries Ejections %	10 100 10.0%	20 100 20.0%	30 200 15%
Total	Neck Injuries Ejections %	20 200 10.0%	40 200 20.0%	60 400 15%

PRELIMINARY RESULTS

Some very limited results are shown in the next three tables. The first table shows the importance of the risk conditions at time of ejection. The fatality rate is a function of the speed and altitude at time of ejection. The second table presents the fatality rates for the different modes of ejection (jettison or through-the-canopy) for each of the speed and altitude regions. The overall difference between the modes is due to the difference in the low speed - low altitude risk situation. The third table shows a partition of the low altitude - low speed ejections by the number of ejections per incident and the mode of ejection. The startling feature, here, is that the overall difference in fatality rates in this low altitude, low speed situation between the modes of ejection is concentrated in the multiple-seat aircrafts. The fourth table then presents the contribution of the ejections from multiple seat aircraft at low altitude - low speed conditions to the overall difference between the two modes of ejection. These findings are preliminary and an explanation of these observed differences has not been determined.

Fatality Rates for Various Categories of Speed and Altitude at the Time of Ejection for AAES (Types 1,2,3,5 and 6 Ejections) From 1 January 1969 Through 31 December 1979 Experience Data

Altitude	F= fatalities T= total ejections %= F/T	Speed			Total
		Low (<200)	Med. (200-500)	High (>500)	
Low (<200')	F T	110 452	18 26	14 16	142 494
	%	24.3	69.2	87.5	28.7
Medium (200-5,000)	F T	25 299	29 228	11 16	65 543
	%	8.4	12.7	68.8	12.0
High (>5,000')	F T	3 112	16 209	9 18	28 339
	%	2.7	7.7	50.0	8.3
Total	F T	138 863	63 463	34 50	235 1,376
	%	16.0	13.6	68.0	17.1

Fatality Rates for "Through-the-Canopy" (TC) and "Jettison Canopy" (JC) Types of Ejection Seats for Various Categories of Speed and Altitude for AAES (Types 1,2,3,5 and 6 Ejections) From 1 Jan 1969 Through 31 Dec 1979 Experience Data

Altitude		Speed						Total		Total
		Low (<200 KTS)		Med. (200-500)		High (>500 KTS)				
		TC	JC	TC	JC	TC	JC	TC	JC	
Low (<200')	F	36	74	5	13	3	11	44	98	142
	T	87	365	8	18	3	13	98	396	494
	%	41.4	20.3	62.5	72.2	100.0	84.6	45.4	24.7	28.7
Medium (200-5,000)	F	5	20	4	25	2	9	11	54	65
	T	58	241	41	187	3	13	102	441	543
	%	8.6	8.2	9.8	13.4	66.7	69.2	10.8	12.2	12.0
High (>5,000')	F	0	3	3	13	1	8	4	24	28
	T	9	103	28	181	4	14	41	298	339
	%	0	2.9	10.7	7.2	25.0	57.1	9.7	8.1	8.3
Total	F	41	97	12	51	6	28	59	176	235
	T	154	709	77	386	10	40	241	1,133	1,376
	%	26.6	13.7	15.6	13.2	60.0	70.0	24.5	15.5	17.1

Fatality Rates for TC and JC Ejections at Low Altitude (<200') and Low Speed (<200#kts) for Types 1,2,3,5 and 6 During the 1 January 1969 Through 31 December 1979 Period

Number of Seats and Number of Ejections			Mode of Ejection: TC	Mode of Ejection: JC	Total
Single Seat Aircraft	Single Ejection	F	4	22	26
		T	19	131	150
		%	21.1	16.8	17.3
Multiple Seat Aircraft	Single Ejection	F	9	19	28
		T	17	55	72
		%	52.9	34.5	38.9
	Multiple Ejection	F	23	33	56
		T	51	179	230
		%	45.1	18.4	24.3
Total		F	36	74	110
		T	87	365	452
		%	41.4	20.3	24.3

The Fatality Rates Partitioned by Two Modes of Ejection (TC or JC) and by Two Risk Categories (Low Altitude, Low Speed for Multiple Seat Aircraft or All Others) Based Upon All Ejections (Types 1,2,3,5 and 6) During the Period 1 January 1969 Through 31 December 1979

Risk Category		Mode of Ejection		Total
		TC	JC	
Multiple Seat Aircraft Low Speed and Low Altitude at Ejection	F	32	52	84
	T	68	234	302
	%	47.1	22.2	27.8
All Other Risk Categories	F	27	124	151
	T	173	901	1,074
	%	15.6	13.8	14.1
Total	F	59	176	235
	T	241	1,135	1,376
	%	24.5	15.5	17.1

SUMMARY AND CONCLUSIONS

NAVWESA is currently examining the U.S. Navy AAES data from a statistical viewpoint and not from an engineering viewpoint. One of the purpose of the examination is to provide some feedback to the engineers and decision makers on various questions about design factors. Another purpose is to provide feedback to pilots and physiologists on the conditions and situations affecting survival.

The analysis effort has just recently been undertaken. The analytical tools employed in the analysis have included multivariate analysis and its discrete counterpart multivariate cross-classification analysis. These techniques allow for the simultaneous examination of several variables at one time and for the measurement of interaction effects among the variables. The emphasis has been on the application of quantitative methods to these data and not on the physical, engineering or medical analyses.

CONCLUSIONS

* The statistical procedures to be employed are determined by the type and the methods by which the data are generated.
* Imbalance in data can lead one astray if adjustment for the imbalance is not made.

* Ignoring contributing factors can cause one to draw erroneous conclusions.

* Knowledge of the physical and physiological systems must be used in conjunction with the statistical evidence to arrive at the appropriate conclusion.

Reporting of all the factual data is very important for all users. Comprehensive reporting of the factual data is essential and should be separated from any conclusions or inferences. Conclusions, diagnoses, or inferences should be identified and reported, but separated from the factual data.

ANALYSES

PRELIMINARY OVERVIEW ANALYSES OF U.S. NAVY AIRCREW AUTOMATED ESCAPE SYSTEMS (AAES) IN-SERVICE USAGE DATA

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INTRODUCTION

This paper examines 1,816 aircrew involved in U.S. Navy aviation mishaps involving ejection seat equipped Navy aircraft during the eleven year period 1 January 1969 through 31 December 1979. Of these 1,816 individual aircrew member cases:

- o 1,391 (76.6 percent) involved ejection or attempt to eject
- o 283 (15.6 percent) did not involve an attempt to eject
- o 142 (7.9 percent) unknown whether an attempt to eject was made.

There were 1,234 survivors (68.0 percent) and 582 fatalities (32.0 percent) in this population:

Survivors (1,234)

- o 1,155 (93.6 percent) ejected or attempted to eject
- o 68 (5.4 percent) did not attempt to eject
- o 11 (0.9 percent) unknown whether an attempt to eject was made

Fatalities (582)

- o 236 (40.5 percent) ejected or attempted to eject
- o 215 (37.0 percent) did not attempt to eject
- o 131 (22.5 percent) unknown whether an attempt to eject was made.

Thus, 76.6 percent of the total population (those attempting ejection) accounted for 93.6 percent of the survivors; while 23.4 percent of the population (those either not attempting or whose attempt status was not known) accounted for only 6.4 percent of the survivors and 59.5 percent of the fatalilities. The overall survival rates for each of the ejection classifications were:

- o 83.0 percent for those attempting ejection,
- o 24.0 percent for those not attempting ejection,
- o 7.7 percent for those whose attempt status is unknown, and
- o 16.2 percent for the combination of those not attempting ejection and those whose attempt status is unknown.

Also, the 1,234 survivors sustained varying degrees of injury ranging from "BRAVO" (major injury) to "GOLF" (minimal or no injury). Of those survivors who sustained "BRAVO" injuries:

- o 200 (92.6 percent) ejected or attempted to eject
- o 14 (6.5 percent) did not attempt to eject
- 2 (1.0 percent) unknown whether an attempt to eject was made.

DATA SOURCE AND DEFINITIONS

Data extracted from Medical Officer's Reports (MORs) by the Naval Safety Center, Norfolk, Virginia, were examined. The data were encoded by the Naval Safety Center using the following injury and type ejection attempt definitions promulgated in OPNAVINST 3750.6L, dated 27 October 1978 and the MOR Manual of Code Classification:

o Type Ejection

1- Accomplished (free of aircraft)
2- Accomplished (did not clear aircraft)
3- Attempted (not accomplished)
4- Seat ejected on impact (terrain)
5- Inadvertent ejection
6- Underwater ejection
7- Unknown if attempt was made
8- Suspected ejection
0- Definitely not attempted

o Type Injury

"ALPHA" - Fatal
"BRAVO" - Major
"FOXTROT" - Minor
"GOLF" - No injury or minimal injury
"LIMA" - Lost
"UNIFORM - Unknown/missing

Definitions of "BRAVO", "FOXTROT" and "GOLF" injuries as established by OPNAV Instruction 3750.6L, dated 27 October 1978 are provided in the appendix.

Since 1 January 1974 the definition of an ejection has included all cases in which an aircrew member has attempted to initiate the escape system.

THE TOTAL POPULATION

As mentioned above, the overall survival rate for our population was 68.0 percent. However, examination of underlying rates by various categories of ejection types reveals wide variances.

Tables 1 and 2 give overall views of ejection and non-ejection totals, survivors and non-survivors. In these tables survivors, "BRAVO" injuries, and fatalities are compared by ejection attempt type and ejection envelope. The data fall into two major categories: 1) ejection attempts and 2) non-attempts or cases where attempt status was unknown. In these categories:

- o 1,391 ejections were attempted with a survival rate of 83.0 percent and
- o 425 were non-ejections or ejection attempt unknown - survival rate 18.6 percent.

These are natural and obvious sub-populations of the data. Because we are interested in the in-service usage and performance of escape systems, attempts, successful and unsuccessful, to use the systems are of primary concern. Study of the non-attempts and unknown will shed light on conditions resulting in non-use of the escape system and may aid in determining the causes for out of envelope escape attempts.

A graphic comparison (Figure 1) of the contribution of each type of ejection attempt status to the survivor population versus the fatality population shows that the non-attempt and unknown categories contribute very heavily to the fatalities but their impact upon the survivor population was minimal. Furthermore, if out-of-envelope ejection attempts are considered along with non-attempts and unknowns (Figure 2), the contribution to fatalities increases to 82.5 percent (465 fatalities). Clearly the greatest potential for reducing fatalities lie in the analysis of these areas. A detailed case-by-case examination must be undertaken, and is planned, to determine the causes for failure to eject and for ejecting out of envelope.

ATTEMPTED EJECTIONS

As might be expected, there was a dramatic increase in survival rate as we restricted our area of consideration to clear-of-aircraft ejections. Here we found the majority of our survivors and consequently it will be here that we study injury/fatality patterns which may point to cause factors. But first, let's consider the less successful attempts to eject.

Normal ejection statistics are compiled from types 1,2,3,5 and 6 ejections with the exception of type 3 survivors. These are usually omitted because the aircrew survives not because of the escape system but in spite of some escape system malfunction. Thus, since the type 3 fatalities represent only half of the type 3 cases the frequency with which serious deficiencies occur in escape systems is significantly understated in the normal statistic compilations.

In all cases where ejection was accomplished but the seat did not clear the aircraft (Type 2), the ejectee did not survive. Most were reported as out of the escape system envelope because the seat did not have time to clear the aircraft before ground impact. The one exception to this pattern involves failure of sequencing signals to initiate rear seat ejection following canopy jettisoning at a terrain clearance altitude greater than 10,000 ft.

There was a 50.0 percent survival rate in the 4 underwater ejections. Although specification MIL-S-18471 requires escape system components to function under water at depths down to, and including 100 ft., underwater ejection is a form of out of envelope escape because:

- o Airframe deformation resulting from water impact might preclude operation of an otherwise functional aircrew automated escape system (AAES)
- o Aircraft water impact forces might damage AAES in a manner precluding AAES operation
- o Aircraft water impact forces might incapacitate crew precluding their initiation of escape or survival following escape.

INADVERTENT AND ACCOMPLISHED CLEAR OF AIRCRAFT EJECTIONS

The primary focus of this preliminary investigation has been on the remaining types of ejection attempts: inadvertent ejections and ejections accomplished free of aircraft (types 5 and 1 respectively). Inadvertent ejections are included here because they all happened to have been clear of the aircraft during this eleven year sample. Of the 1,337 ejectees in this group (types 1 and 5):

- o 202 (15.1 percent) were fatalities
- o 1,135 (84.9 percent) were survivors;

of the fatalities:

- o 138 (68.3 percent) were recovered ("ALPHA")
- o 64 (31.7 percent) were lost ("LIMA") or unknown/ missing ("UNIFORM"); and

of the survivors:

- o 196 (17.3 percent) sustained major ("BRAVO") injuries
- o 310 (27.3 percent) sustained minor ("FOXTROT") injuries
- o 629 (55.4 percent) sustained minimal or no ("GOLF") injuries.

Yearly distributions of ejectee totals and rates of injuries for inadvertent and clear of aircraft ejectees are presented in Tables 3 and 4. Figures 3 through 6 are graphical representations of these data. The numbers of fatalities and major injuries declined during the first half of the eleven year span and remained relatively stable in the final half reflecting, in part, an overall reduction in ejections per year during the first half of this span. Rates of fatalities and major injuries show more erratic trends to some extent because of decreasing total ejections over the years. (This aspect is treated in greater detail in a paper to be presented entitled: "Problems With the Use of Percentages in the Analysis of AAES Data").

ROLES OF TERRAIN AND ENVELOPE FOR TYPE 1 AND 5 EJECTEES

The highest survival rate among major subgroupings was found to be among the within-system-envelope, overland ejections (see Tables 5 through 7). Terrain apparently has very little influence on the survival rate; while being within the escape system envelope vastly increases the likelihood of survival. Looking at fatalities (Table 8 and Figure 7), the dominance of the envelope is not as apparent and terrain does appear to influence to a limited degree the effect of the envelope. The percentage of fatalities in the out of envelope overland category is more than twice that for the in envelope overland ejection.

Terrain is important when considering percentage of lost or drowned ejectees. Since most type 1 and 5 ejectees classified as lost were over water (60 of 63, 95.2 percent) and all drowning cases were over water, developing percentages with respect to total ejections, i.e., overland and overwater ejections, can result in a significant understatement of the problem than would be the case if only the high-risk overwater population were considered. For example, there were 81 type 1 and 5 ejectees who were lost or drowned - 6.1 percent of the total type 1 and 5 population of 1,337. However, there were 78 type 1 and 5 overwater ejectees who were lost or drowned, representing 12.3 percent of the overwater ejectee population; the population which has the greatest risk of drowning or of being lost.

CAUSES OF DEATH OF TYPE 1 AND 5 EJECTEES

The most frequently recorded causes of death for ejectees (types 1 and 5) listed as either in envelope or out of envelope (195 fatalities) are:

- Outside Escape Envelope - 54 (27.6 percent)
- Ground Impact - 42 (21.5 percent)
- Misuse of Survival Equipment - 10 (5.1 percent)
- Lines/Parachute Entanglement - 7 (3.6 percent)
- Fireball in Air - 4 (2.1 percent)
- Other - 4 (2.1 percent)
- Contact with Canopy/Canopy Bow - 3 (1.5 percent)
- Wind Blast - 3 (1.5 percent)

In addition, 29.2 percent had no cause of death coded and the remaining 5.8 percent had various cause codes.

Figures 8 and 9 show all causes of death in type 1 and 5 ejectees and their number of occurrences by ejection envelope. Note on Figure 7, eight fatalities attributed to "Aircraft Disintegration". This was not the recorded cause of death but was found to be the condition of the aircraft at ejection. Since disintegration of the aircraft will in most cases degrade or inhibit escape system performance, the recorded causes of death were made subordinate in the analysis. Also noteworthy is the quantity of fatalities caused by "Ground Impact" (13, 17.1 percent) after reportedly initiating in envelope ejections. In many instances these probably were out of envelope since no system malfunction was reported.

ROLES OF ALTITUDE, SPEED, ATTITUDE AND MANUEVER IN TYPE 1 AND 5 EJECTIONS

Presented below is a comparison of altitude statistics for fatal (Injury codes "ALPHA, "LIMA" and "UNIFORM"), survivor (Injury codes "BRAVO", "FOXTROT" and "GOLF"), major injury ("BRAVO"), and minor/minimal/no injury ("FOXTROT" and "GOLF") categories for type 1 and 5 ejectees. Ejectee totals are only those for which altitude was recorded (altitude given in feet above ground level).

	Ejectees	Alt. Mean	Alt. Median
Fatalities	197	1,829	100
Survivors	1,135	3,722	1,200
Major Injuries	196	3,912	1,625
Minor/Minimal/No Injuries	939	3,682	1,000

A similar comparison for speed (KIAS) gives:

	Ejectees	Speed Mean	Speed Median
Fatalities	181	212	150
Survivors	1,121	180	191
Major Injuries	194	222	200
Minor/Minimal/No Injuries	927	185	180

The above seem to indicate that low altitude and relatively low speeds contribute to fatalitites; major injuries do not seem to be so affected. However, much more detailed analysis is required.

An overview of aircraft attitude (pitch and bank) for type 1 and 5 ejections reveals:

- o 134 (10.0 percent with 66.4 percent survival rate) had no indication of pitch or bank, and

- o 250 (18.7 percent with 92.0 percent survival rate) were straight and level.

The remaining 953 ejectees (71.3 percent with 85.6 percent survival rate) had at a minimum the direction of pitch or bank. Of these:

- o 158 (16.6 percent with 93.7 percent survival rate) had pitch up in the 1 to 45 degree range,
- o 382 (40.1 percent with 84.3 percent survival rate) had pitch down in the 1 to 45 degree range,
- o 8 (0.8 percent with 87.5 percent survival rate) had pitch up greater than 45 degrees
- o 119 (12.5 percent with 66.4 percent survival rate) had pitch down greater than 45 degrees
- o 140 (14.7 percent with 93.6 percent survival rate) had pitch up with no degrees coded
- o 46 (4.8 percent with 91.3 percent survival rate) had pitch down with no degrees coded
- o 34 (3.6 percent with 91.2 percent survival rate) showed zero degrees pitch,
- o 66 (6.9 percent with 84.8 percent survival rate) had blank pitch code with some bank indicated;

while for bank:

- o 253 (26.5 percent with 89.3 percent survival rate) were left or right in the 1 to 45 degree range,
- o 99 (10.4 percent with 63.7 percent survival rate) were left or right greater than 45 degrees,
- o 71 (7.5 percent with 83.1 percent survival rate) had left or right indicated but no degrees,
- o 141 (14.8 percent with 94.3 percent survival rate) showed zero degrees, and
- o 389 (40.8 percent with 86.1 percent survival rate) were blank with some pitch indicated.

The manuever at time of ejection was recorded for 404 of the 1,337 type 1 and 5 ejectees. The most frequently observed manuevers being:

- o Rolling (98 ejections, 85.7 percent survival rate)
- o Inverted (67, 65.7)
- o Nose down spin (57, 89.5)
- o Disintegration (49, 63.3)
- o Flat spin (35, 91.4)
- o Mushing (35, 94.3)
- o Unknown (24, 45.8)

with various other manuevers indicated for 39 other cases. The survival rate was 78.7 percent for these 404 ejections as compared to 87.6 percent for the group of cases with no manuever coded. Survival rates of the inverted, disintegration and manuever-unknown categories seem to account for this lower rate.

Again, the data presented here on altitude, speed, attitude and manuever are very preliminary and have been developed primarily as an aid in the development of plans for further investigation.

SUMMARY

From this preliminary examination of aviation mishaps involving individuals in ejection seat equipped Navy aircraft, it appears that the greatest potential payoff in the effort to reduce fatalities, major injuries, lost time and aircraft is in the areas of non-attempts and out-of-envelope ejections. The data also suggests that low altitude, low speed or very high speed, adverse attitude, abnormal manuevers and unfriendly terrain all have a significant negative influence on survival rates.

Detailed analyses are planned in order to confirm or refute these preliminary findings. Special problems to be addressed will include, but not be limited to:

- o Through-the-Canopy versus Jettisoned-Canopy
- o Flail, Windblast and Tumble
- o Vertebral Fractures
- o Head/Neck Injuries
- o Helmet Loss
- o Survival Equipment Usage.

DISTRIBUTION OF SURVIVORS, MAJOR ("B") INJURED, AND FATALITIES AMONG ALL USN AVIATORS IN EJECTION SEAT EQUIPPED AIRCRAFT INVOLVED IN REPORTED AVIATION MISHAPS BY TYPE OF EJECTION ATTEMPTED

1 JANUARY 1969 THROUGH 31 DECEMBER 1979

EJECTION ATTEMPT STATUS	EJECTION DESCRIPTION	EJECTION CODE	NUMBERS OF AIRCREWMEN			
			SURVIVORS			
			MAJOR ("B") INJ.	TOTAL	FATALITIES	TOTAL
EJECTION ATTEMPTED	(A) IN ENVELOPE CLEAR OF AIRCRAFT	1	174	1,094	73	1,167
		5	6	18	3	21
(SUBTOTAL)			180	1,112	76	1,188
	(B) POSSIBLY OUT OF ENVELOPE	1	8	12	7	19
		5	—	—	—	—
(SUBTOTAL)			8	12	7	19
	(C) OUT OF ENVELOPE	1	8	11	119	130
		5	—	—	—	—
		2	0	0	15	15
(SUBTOTAL)			8	11	134	145
(SUBTOTAL (B) + (C))			16	23	141	164
	(D) UNDERWATER	6	2	2	2	4
	(E) NOT ACCOMPLISHED	3	2	18	17	35
(SUBTOTAL)			200	1,155	236	1,391
EJECTION NOT ATTEMPTED	(NOT CODED)	(BLANK)	11	62	157	219
	EJECTED ON IMPACT	4	3	3	22	25
	DEFINITELY NOT ATTEMPTED	0	0	3	36	39
(SUBTOTAL)			14	68	215	283
EJECTION ATTEMPT UNKNOWN	(NOT CODED)	(BLANK)	1	10	11	21
	SUSPECTED	8	0	0	2	2
	UNKNOWN	7	1	1	118	119
(SUBTOTAL)			2	11	131	142
TOTAL			216	1,234	582	1,816

MAJOR ("B") INJURED RATES, SURVIVAL RATES AND FATALITY RATES BY TYPE OF EJECTION ATTEMPTED FOR ALL USN AVIATORS IN EJECTION SEAT EQUIPPED AIRCRAFT INVOLVED IN REPORTED AVIATION MISHAPS

1 JANUARY 1969 THROUGH 31 DECEMBER 1979

EJECTION ATTEMPT STATUS	EJECTION DESCRIPTION	EJECTION CODE	NUMBERS OF AIRCREWMEN: SURVIVORS: MAJOR ("B") INJ. (%)(1)	SURVIVORS: TOTAL (%)(2)	FATALITIES (%)(2)
EJECTION ATTEMPTED	(A) IN ENVELOPE CLEAR OF AIRCRAFT	1	15.9 (1)	93.7 (2)	6.3 (2)
		5	28.6 (1)	85.7 (2)	14.3 (2)
(SUBTOTAL)			16.2 (1)	93.6 (2)	6.4 (2)
	(B) POSSIBLY OUT OF ENVELOPE	1	66.7 (1)	63.2 (2)	36.8 (2)
		5	– (1)	– (2)	– (2)
(SUBTOTAL)			66.7 (1)	63.2 (2)	36.8 (2)
	(C) OUT OF ENVELOPE	1	72.7 (1)	8.5 (2)	91.5 (2)
		5	– (1)	– (2)	– (2)
		2	– (1)	0 (2)	100.0 (2)
(SUBTOTAL)			72.7 (1)	7.6 (2)	92.4 (2)
(SUBTOTAL (B) + (C))			69.6 (1)	14.0 (2)	86.0 (2)
	(D) UNDERWATER	6	100.0 (1)	50.0 (2)	50.0 (2)
	(E) NOT ACCOMPLISHED	3	11.11 (1)	51.4 (2)	48.6 (2)
(SUBTOTAL)			17.3 (1)	83.0 (2)	17.0 (2)
EJECTION NOT ATTEMPTED	(NOT CODED)	(BLANK)	17.7 (1)	28.3 (2)	71.7 (2)
	EJECTED ON IMPACT	4	100.0 (1)	12.0 (2)	88.0 (2)
	DEFINITELY NOT ATTEMPTED	0	0 (1)	7.7 (2)	92.3 (2)
(SUBTOTAL)			20.6 (1)	24.0 (2)	76.0 (2)
EJECTION ATTEMPT UNKNOWN	(NOT CODED)	(BLANK)	10.0 (1)	47.7 (2)	52.4 (2)
	SUSPECTED	8	– (1)	0 (2)	100.0 (2)
	UNKNOWN	7	100.0 (1)	0.8 (2)	99.2 (2)
(SUBTOTAL)			18.2 (1)	7.7 (2)	92.3 (2)
TOTAL			17.5 (1)	68.0 (2)	32.0 (2)

(1) REPORTED AS A PERCENTAGE OF SURVIVORS IN EACH CATEGORY

(2) REPORTED AS A PERCENTAGE OF TOTAL EJECTEES IN EACH CATEGORY

AD-A172 051 AIRCREW AUTOMATED ESCAPE SYSTEMS (AAES) IN-SERVICE USAGE DATA ANALYSIS PROGRAM(U) NAVAL AIR SYSTEMS COMMAND WASHINGTON DC F C GUILL FEB 82 2/4

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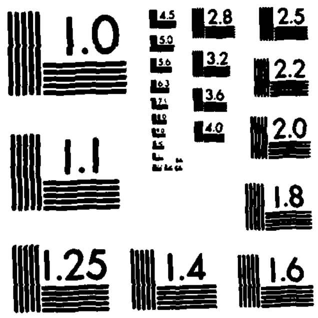
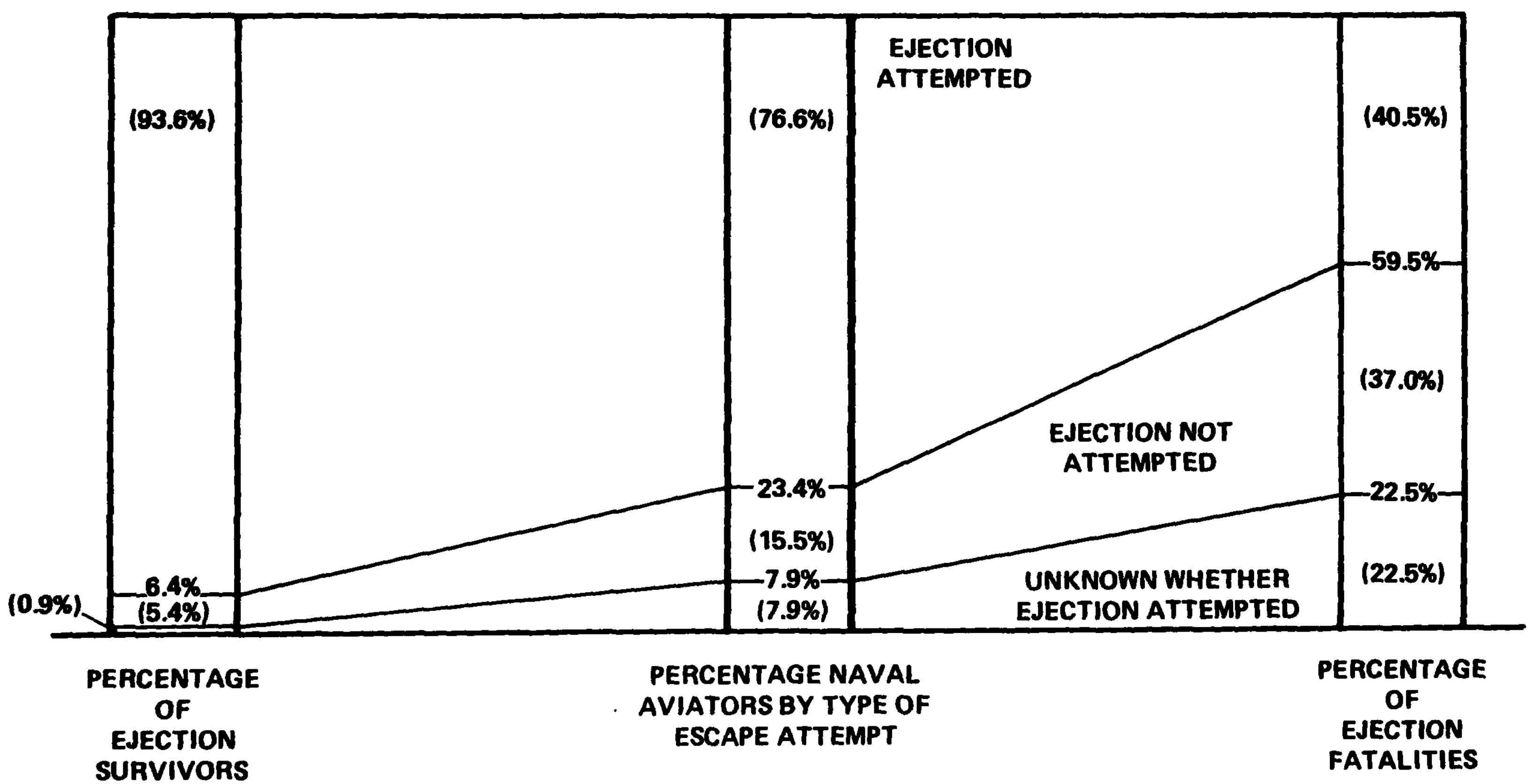


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

COMPARATIVE PERCENTAGE DISTRIBUTIONS OF SURVIVORS, FATALITIES AND ALL NAVAL AVIATORS IN EJECTION SEAT EQUIPPED AIRCRAFT INVOLVED IN REPORTED AVIATION MISHAPS BY TYPE ESCAPE ATTEMPTED (11 YEAR PERIOD, 1,816 AVIATORS) 1 JANUARY 1969 THROUGH 31 DECEMBER 1979



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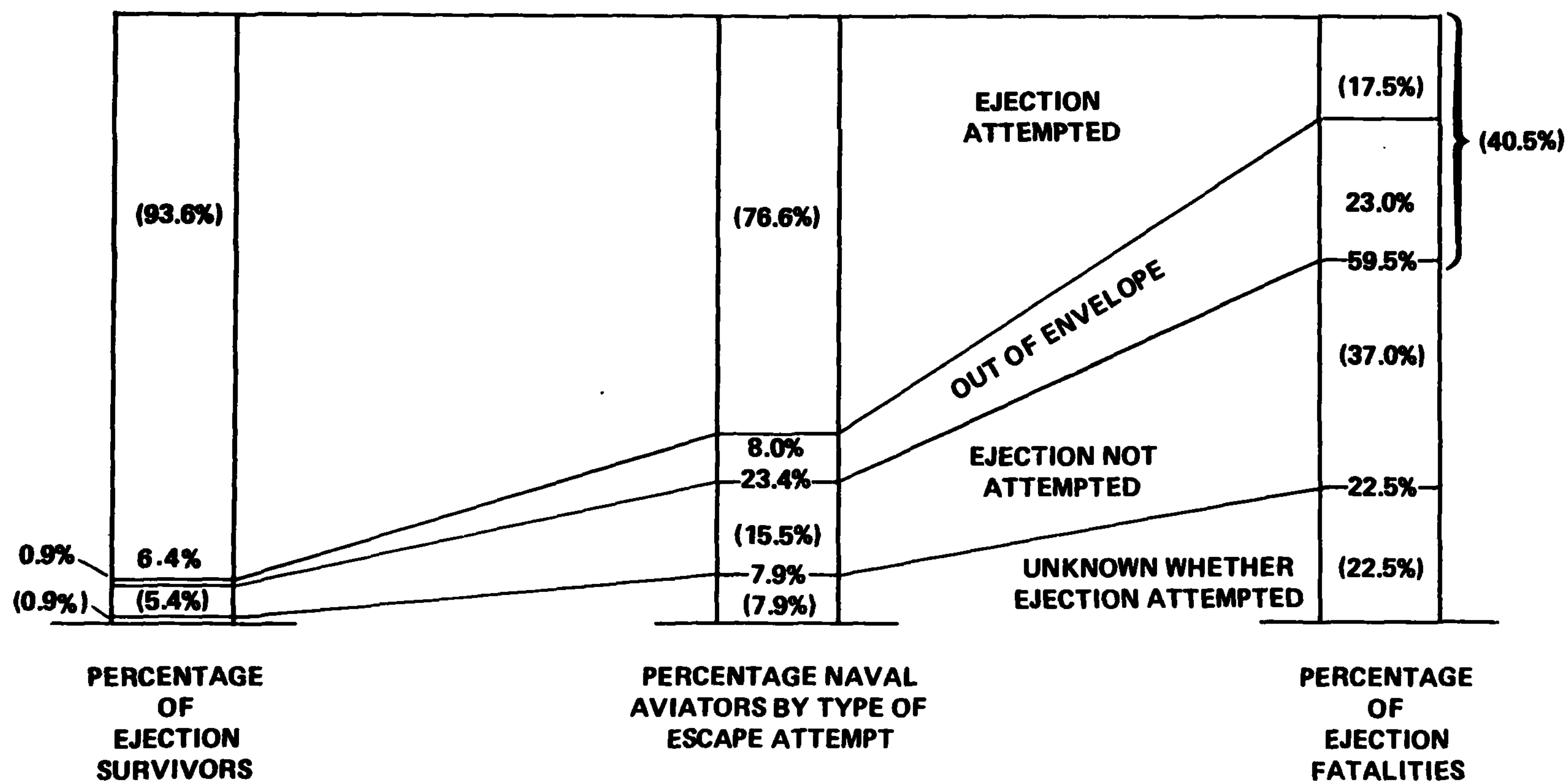


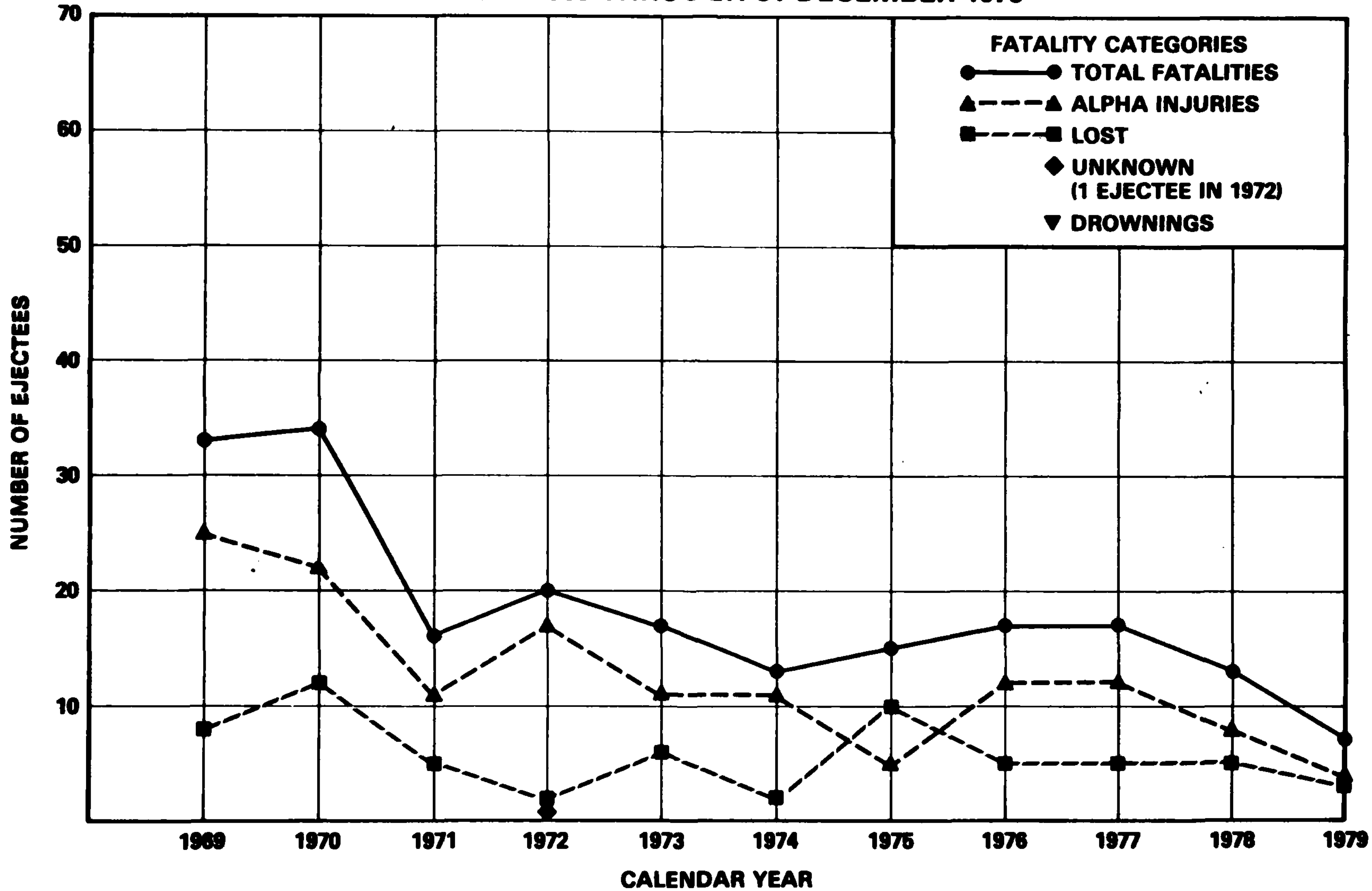
DISTRIBUTION OF INJURIES AMONG CODES 1 AND 5 EJECTEES BY YEAR (INADVERTENT AND ACCOMPLISHED CLEAR OF AIRCRAFT EJECTIONS)

YEAR	FATALITIES				SURVIVORS			
(TOTALS)	A	L	U	TOTAL	B	F	G	TOTAL
1969 (244)	25	8	–	33	30	86	95	211
1970 (197)	22	12	–	34	28	62	73	163
1971 (142)	11	5	–	16	27	29	70	126
1972 (152)	17	2	1	20	29	26	77	132
1973 (126)	11	6	–	17	13	23	73	109
1974 (73)	11	2	–	13	14	12	34	60
1975 (91)	5	10	–	15	14	17	45	76
1976 (86)	12	5	–	17	12	23	34	69
1977 (94)	12	5	–	17	15	16	46	77
1978 (76)	8	5	–	13	8	10	45	63
1979 (56)	4	3	–	7	6	6	37	49
1980								

RATES OF INJURY AMONG CODES 1 AND 5 EJECTEES BY YEAR (INADVERTENT AND ACCOMPLISHED CLEAR OF AIRCRAFT EJECTIONS)

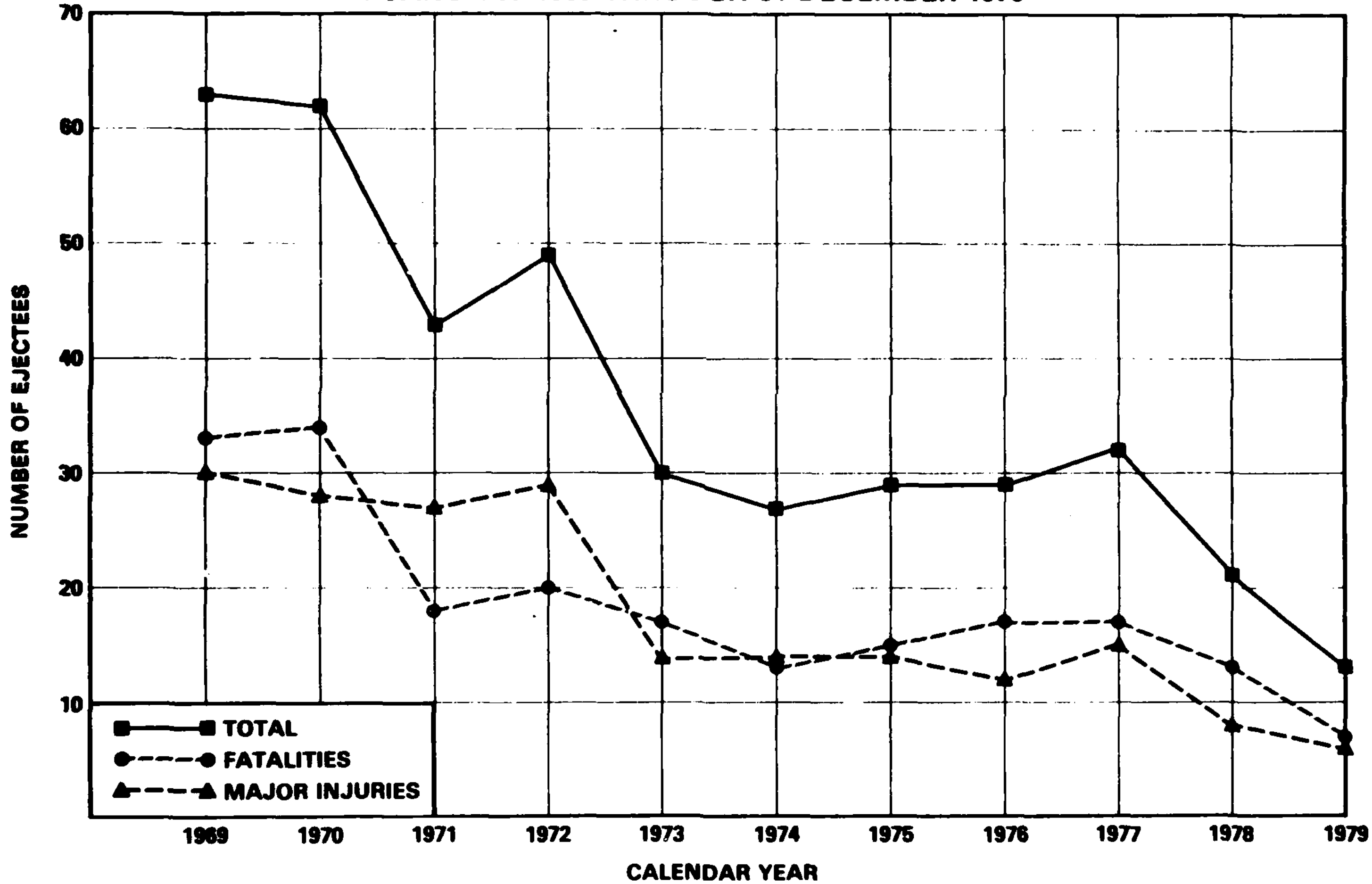
YEAR (TOTALS)	FATALITIES (%)				SURVIVORS (%)			
	A	L	U	TOTAL	B	F	G	TOTAL
1969 (244)	10.2	3.3	–	13.5	12.3	35.2	38.9	86.5
1970 (197)	11.2	6.1	–	17.3	14.2	31.5	37.1	82.7
1971 (142)	7.7	3.5	–	11.3	19.0	20.4	49.3	88.7
1972 (152)	11.2	1.3	0.7	13.2	19.1	17.1	50.7	86.8
1973 (126)	8.7	4.8	–	13.5	10.3	18.3	57.9	86.5
1974 (73)	15.1	2.7	–	17.8	19.2	16.4	46.6	82.2
1975 (91)	5.5	11.0	–	16.5	15.4	18.7	49.5	83.5
1976 (86)	14.0	5.8	–	19.8	14.0	26.7	39.5	80.2
1977 (94)	12.8	5.3	–	18.1	16.0	17.0	48.9	81.9
1978 (76)	10.5	6.6	–	17.1	10.5	13.2	59.2	82.9
1979 (56)	7.1	5.4	–	12.5	10.7	10.7	66.1	87.5
1980								

FATALITIES PER YEAR FOR EJECTION TYPES 1 AND 5
(INADVERTENT AND ACCOMPLISHED CLEAR OF AIRCRAFT EJECTIONS)
1 JANUARY 1969 THROUGH 31 DECEMBER 1979

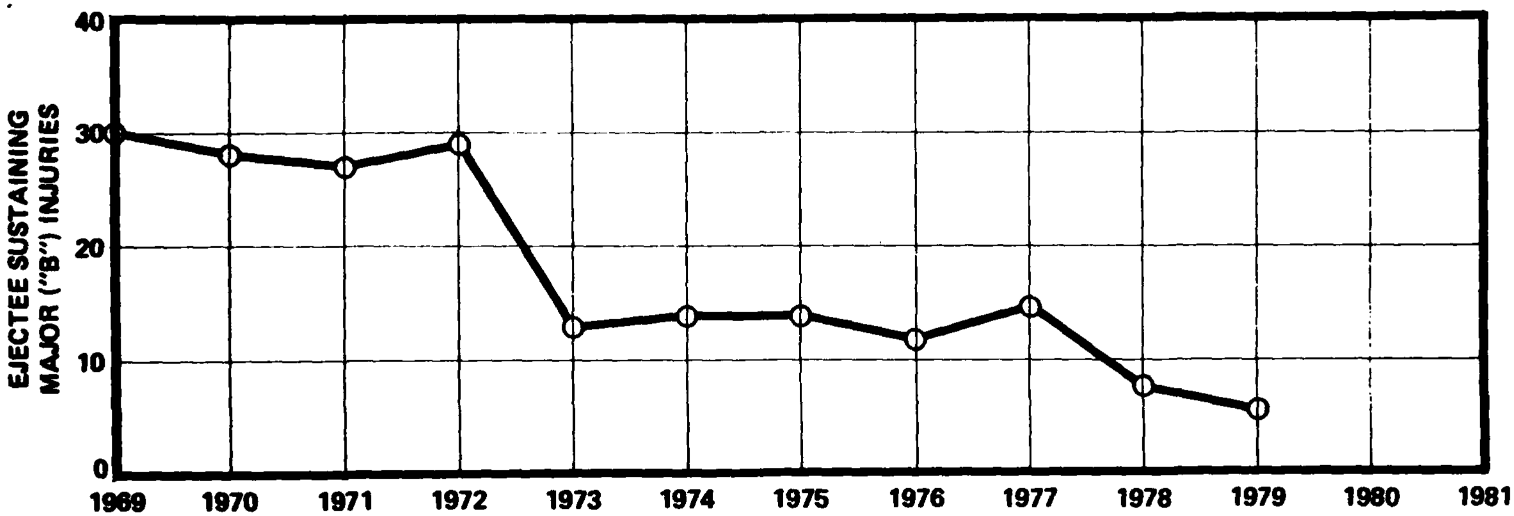


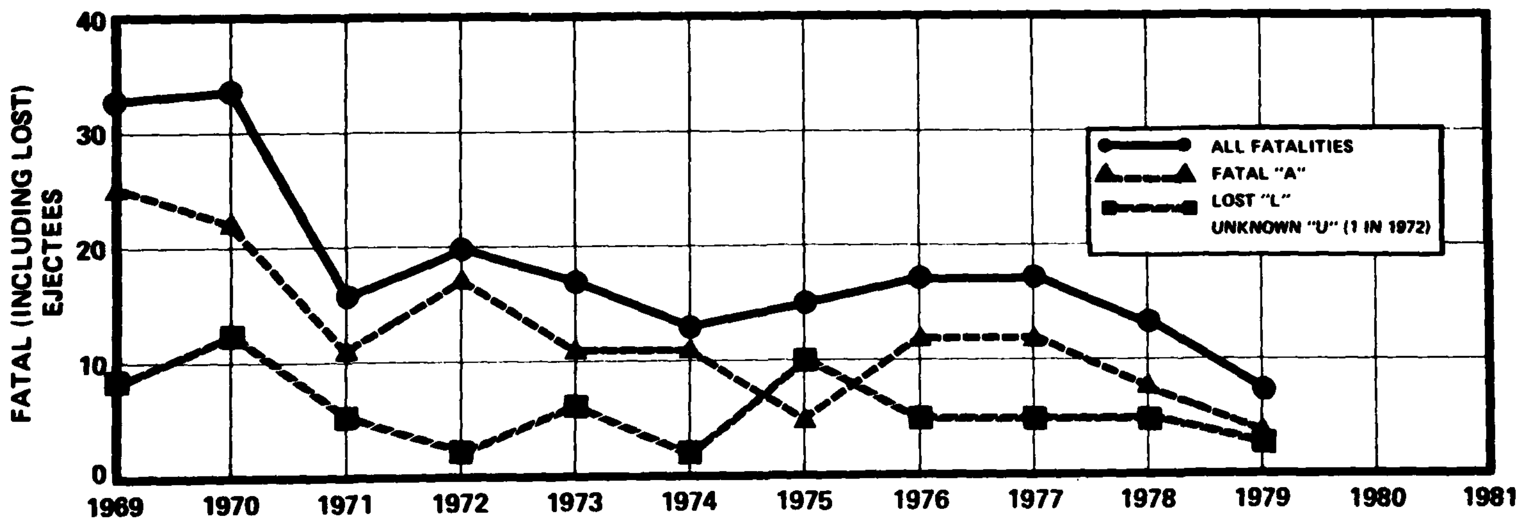
ANNUAL FATALITIES AND MAJOR INJURIES AMONG EJECTION TYPES 1 AND 5

(INADVERTENT AND ACCOMPLISHED CLEAR OF AIRCRAFT EJECTIONS)
1 JANUARY 1969 THROUGH 31 DECEMBER 1979



ANNUAL NUMBERS OF FATALITIES AND MAJOR INJURIES SUSTAINED BY EJECTEES EJECTING "INADVERTENTLY" AND EJECTING "ACCOMPLISHED CLEAR OF AIRCRAFT"

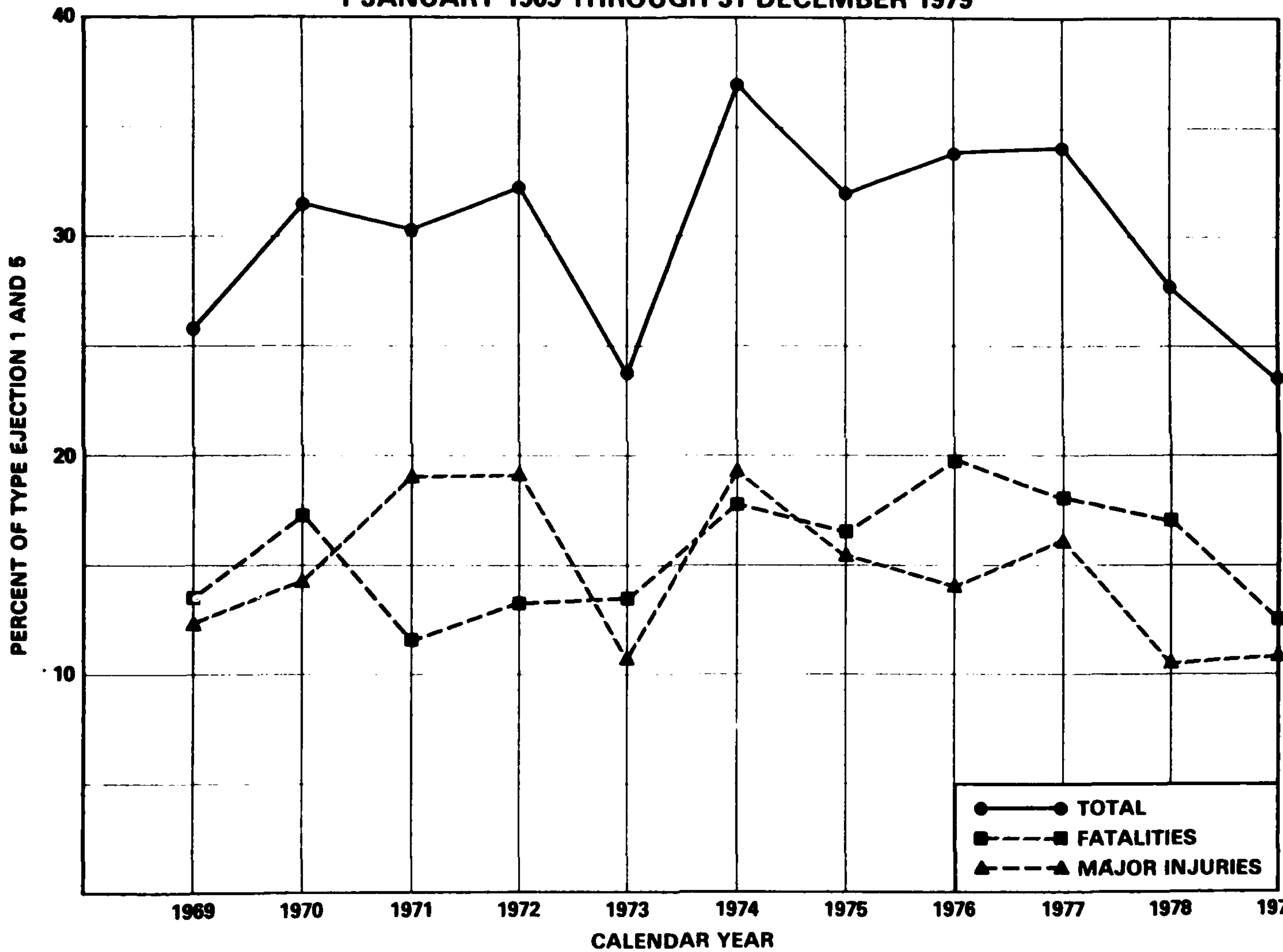




FATALITY AND MAJOR INJURY RATES AMONG TYPE 1 AND 5 EJECTEES

(INADVERTENT AND ACCOMPLISHED CLEAR OF AIRCRAFT EJECTIONS)

1 JANUARY 1969 THROUGH 31 DECEMBER 1979



DISTRIBUTION OF TERRAIN AND EJECTION ENVELOPE FOR TYPE 1 AND 5 EJECTEES

(ACCOMPLISHED CLEAR OF AIRCRAFT AND INADVERTENT EJECTIONS)

1 JANUARY 1969 THROUGH 31 DECEMBER 1979

ENVELOPE \ TERRAIN	OVERWATER EJECTIONS	OVERLAND EJECTIONS	TOTALS
WITHIN SYSTEM ENVELOPE	579	609	1188
POSSIBLY OUT OF SYSTEM ENVELOPE	10	9	19
OUT OF SYSTEM ENVELOPE	47	83	130
TOTALS	636	701	1337

ROLES OF TERRAIN AND EJECTION ENVELOPE IN SURVIVORS AMONG TYPE 1 AND 5 EJECTEES

(ACCOMPLISHED CLEAR OF AIRCRAFT AND INADVERTENT EJECTIONS)

1 JANUARY 1969 THROUGH 31 DECEMBER 1979

ENVELOPE \ TERRAIN	OVERWATER EJECTIONS	OVERLAND EJECTIONS	TOTALS
WITHIN SYSTEM ENVELOPE	536	576	1112
POSSIBLY OUT OF SYSTEM ENVELOPE	3	9	12
OUT OF SYSTEM ENVELOPE	4	7	11
TOTALS	543	592	1135

ROLE OF TERRAIN AND EJECTION ENVELOPE IN TYPE 1 AND 5 EJECTEE SURVIVAL RATES

(ACCOMPLISHED CLEAR OF AIRCRAFT AND INADVERTENT EJECTIONS)

1 JANUARY 1969 THROUGH 31 DECEMBER 1979

ENVELOPE / TERRAIN	OVERWATER EJECTIONS	OVERLAND EJECTIONS	TOTALS
WITHIN SYSTEM ENVELOPE	92.6%	94.6%	93.6%
POSSIBLY OUT OF SYSTEM ENVELOPE	30.0%	100.0%	63.2%
OUT OF SYSTEM ENVELOPE	8.5%	8.4%	8.5%
TOTALS	85.4%	84.5%	84.9%

ROLES OF TERRAIN AND EJECTION ENVELOPE IN FATALITIES AMONG TYPE 1 AND 5 EJECTEES

(ACCOMPLISHED CLEAR OF AIRCRAFT AND INADVERTENT EJECTIONS)

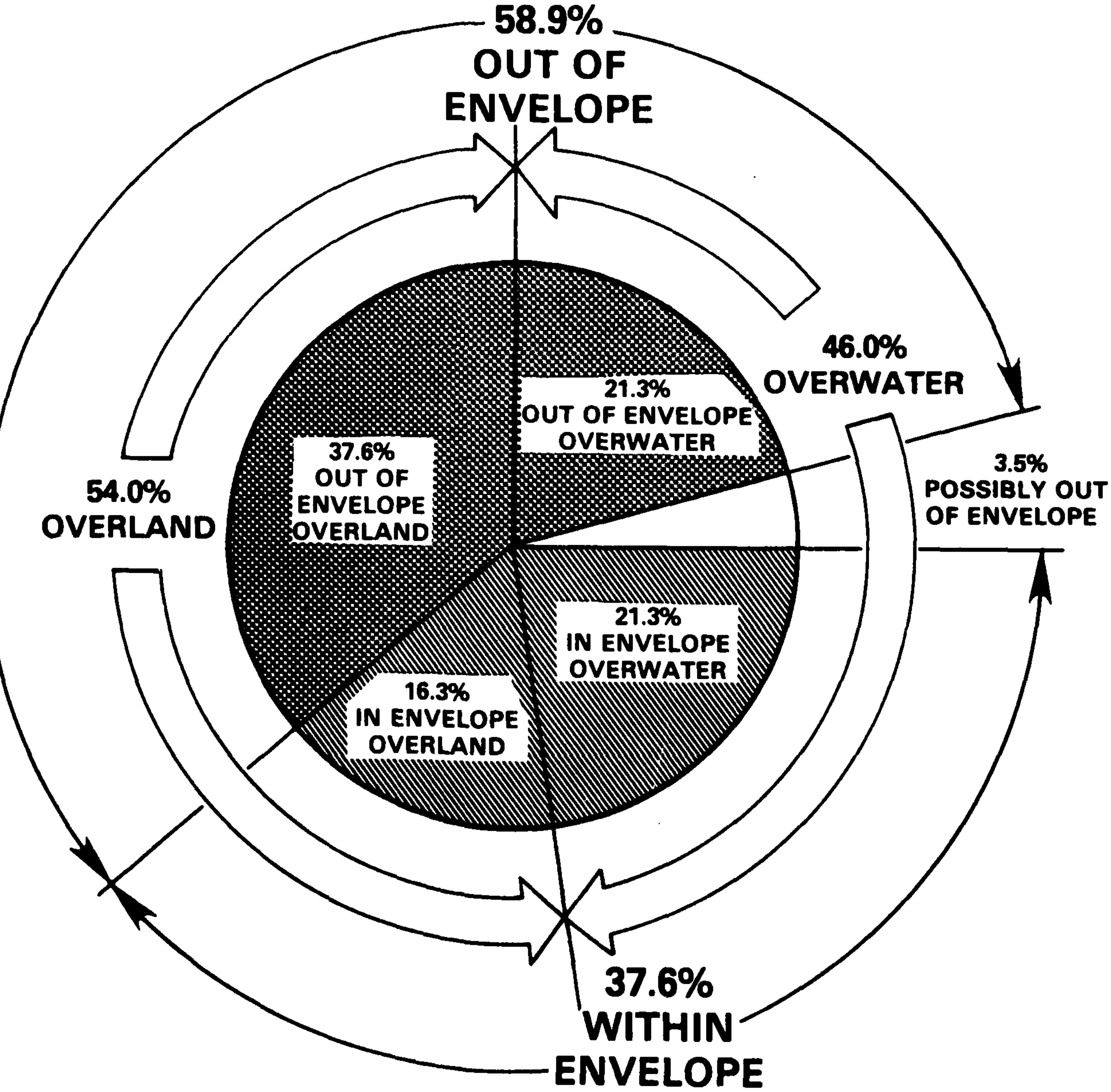
1 JANUARY 1969 THROUGH 31 DECEMBER 1979

TERRAIN / ENVELOPE	OVERWATER EJECTIONS	OVERLAND EJECTIONS	TOTALS
WITHIN SYSTEM ENVELOPE	43	33	76
POSSIBLY OUT OF SYSTEM ENVELOPE	7	0	7
OUT OF SYSTEM ENVELOPE	43	76	119
TOTALS	93	109	202

ROLES OF TERRAIN AND EJECTION ENVELOPE IN FATALITIES AMONG TYPE 1 AND 5 EJECTEES

(202 TOTAL FATALITIES)
(ACCOMPLISHED CLEAR OF AIRCRAFT AND INADVERTENT EJECTIONS)

1 JANUARY 1969 THROUGH 31 DECEMBER 1979



CAUSE OF DEATH
FOR
FATALITIES AMONG THOSE EJECTING CLEAR OF AIRCRAFT AND WITHIN SYSTEM ENVELOPE

(TYPE 1 AND 5 EJECTIONS)

1JAN 1969 THROUGH 31 DECEMBER 1979

QUANTITY	LISTED CAUSE OF DEATH
25	CAUSE OF DEATH NOT CODED
13	GROUND IMPACT
9	MISUSE OF SURVIVAL EQUIPMENT
8	AIRCRAFT DISINTEGRATING
	3 CAUSE OF DEATH NOT CODED
	2 GROUND IMPACT
	1 CONTACT WITH AIRCRAFT EXTERIOR
	1 EJECTION FORCES
	1 WINDBLAST
6	LINE/PARACHUTE ENTANGLEMENT
4	FIREBALL IN AIR
2	OTHER
2	PERSONAL/SURVIVAL EQUIPMENT NECESSARY
1	CONTACT WITH CANOPY/CANOPY BOW
1	CONTACT WITH SEAT ON GROUND
1	DRAGGING
1	INCAPACITATED
1	OUTSIDE ESCAPE ENVELOPE
1	POOR BODY POSITION
1	WINDBLAST

CAUSE OF DEATH
FOR
FATALITIES AMONG THOSE EJECTING CLEAR OF AIRCRAFT BUT OUTSIDE SYSTEM ENVELOPE

(TYPE 1 AND 5 EJECTIONS)

1 JANUARY 1969 THROUGH 31 DECEMBER 1979

QUANTITY	LISTED CAUSE OF DEATH
54	OUTSIDE ESCAPE ENVELOPE
29	CAUSE OF DEATH NOT CODED
27	GROUND IMPACT
2	CONTACT WITH CANOPY/CANOPY BOW
2	OTHER
1	CONTACT WITH AIRCRAFT EXTERIOR
1	EJECTION FORCE
1	LINE/PARACHUTE ENTANGLEMENT
1	MISUSE OF SURVIVAL EQUIPMENT
1	WINDBLAST

APPENDIX A

A-1 "BRAVO" Injury Definition

A-2 "FOXTROT" Injury Definition

A-3 "GOLF" Injury Definition

DEFINITION OF BRAVO INJURY (MAJOR INJURY) APPLICABLE DURING PERIOD 1 JAN 1969 THROUGH 31 DEC 1979

B. BRAVO – MAJOR INJURY. ANY INJURY REQUIRING FIVE (5) DAYS OR MORE HOSPITALIZATION AND/OR "SICK IN QUARTERS." ALSO, ANY OF THE FOLLOWING, REGARDLESS OF HOSPITALIZATION/SICK IN QUARTERS TIME:

1. UNCONSCIOUSNESS DUE TO HEAD TRAUMA (TRANSIENT UNCONSCIOUSNESS DUE TO HYPOXIA, HYPERVENTILATION, G FORCES, ETC., ARE REPORTABLE AS GOLF INJURY).
2. FRACTURES OF ANY BONE EXCEPT SIMPLE FRACTURE OF NOSE OR PHALANGES.
3. TRAUMATIC DISLOCATION OF MAJOR JOINTS/INTERNAL DERANGEMENT OF THE KNEE.
4. MODERATE TO SEVERE LACERATIONS RESULTING IN SEVERE HEMORRHAGE, OR EXTENSIVE SURGICAL REPAIR.
5. INJURY TO ANY INTERNAL ORGAN.
6. ANY THIRD-DEGREE BURNS. A SECOND-DEGREE BURN INVOLVING MORE THAN FIVE (5) PERCENT OF THE BODY SURFACE.

SOURCE: OPNAVINST 3750.6L
27 OCT 1978

DEFINITION OF FOXTROT INJURY (MINOR INJURY) APPLICABLE DURING PERIOD 1 JAN 1969 THROUGH 31 DEC 1979

C. FOXTROT – MINOR INJURY. ANY INJURY LESS THAN MAJOR, BUT RESULTS IN ONE OR MORE DAYS AWAY FROM WORK.

NOTE

HOSPITALIZATION OR RESTRICTION FROM ASSIGNED WORK ACTIVITIES FOR OBSERVATION OR DIAGNOSIS IS NOT A LOST WORKDAY WHEN COMPETENT MEDICAL AUTHORITY DETERMINES THE INDIVIDUAL COULD HAVE RETURNED TO HIS NORMAL JOB WITHOUT IMPAIRMENT OR DISABILITY.

SOURCE: OPNAVINST 3750.6L
27 OCT 1978

DEFINITION OF GOLF INJURY APPLICABLE DURING PERIOD 1 JAN 1969 THROUGH 31 DEC 1979

GOLF – NO INJURY. MINIMAL INJURIES WHICH DO NOT MEET THE CRITERIA FOR MINOR INJURY.

SOURCE: OPNAVINST 3750.6L
27 OCT 1978

PRELIMINARY GENERALIZED THOUGHTS CONCERNING JETTISONED VS. THROUGH-THE-CANOPY EJECTION ESCAPE SYSTEMS

Frederick C. Guill

The U.S. Navy has repeatedly with past and present aircrew automated escape systems (AAES) accepted designs involving either optional or non-optional through-the-canopy ejection. At the same time, the Navy inventory of AAES has included systems requiring canopy jettisoning prior to seat catapult initiation. Several comparative studies have shown significant differences between through-the-canopy ejection and jettisoned canopy ejection vertebral fracture rates and fatality rates; differences suggesting at first glance that through-the-canopy ejection is more dangerous than jettisoned canopy ejetion. Additional techniques have been introduced in recent years: partial-canopy-cutting (TA-7) and total-canopy-fragmentation (AV-8) ejections. In addition, seats in the A3J (A-5) series aircraft (normally canopy jettisoned ejection) were equipped to engage and push the canopy to cause it to pivot up, aft and off in the event the canopy had failed to jettison before the seat began to move.

In the case of the higher incidence of vertebral fractures, an injury causation mechanism based upon study of test films and, more recently, G_z traces has been suggested (Chart I). As a consequence, steps have been taken in the design of a new AAES being procured to modify the ejection seat-canopy interactions during seat-canopy contact and breakthrough which, if the suggested mechanism is correct, should, based upon the latest film and G_z data, result in a significantly lowered incidence of vertebral fractures.

The subject of the differences in fatality rates is discussed statistically in detail in the paper An Analysis of the Fatality Rate Data From "Jettisoned-Canopy" and "Through-Canopy" Ejections From Automated Airborne Escape Systems. There were, during the period 1 January 1969 through 31 December 1979, 237 type 1 and 5 through-the-canopy ejections of which 58 resulted in fatalities. Among these fatalities the bodies of 41 were recovered while 17 were lost. Thirty of the recovered body fatalities occurred over land and eleven over water. Sixteen of the lost were over water and one over land. A case-by-case examination of the records concerning each of the 58 through-the-canopy ejection fatalities did not reveal any evidence suggesting that ejecting through-the-canopy caused, or helped cause, any of the fatalities. None of the 41 recovered bodies and their equipments bore evidence of injury or problems which might have been produced as a consequence of passing through the canopy and which could have caused or helped cause the fatality.

Although there exists considerable information concerning the probable causes of death for most of the lost ejectees, none of the causes suggest that ejecting through-the-canopy was causative of, or contributive to, the fatal outcome. Nonetheless, ignoring that data, it is instructive to examine the probabilities that one, two, three, or more of the lost

ejectees died as a consequence of passing through the canopy while none of the recovered fatalities bore any evidence of such cause of, or contribution to, death. The probability of observing zero (0) cases of such injury or problem given that one, two, three,... x of the lost actually incurred them is given by the formula:

$$(1-x/17)^{41}$$

Thus, assuming that 1 of the lost ejectees sustained such an injury or problem, there would only be an 8.3 per cent probability that such injury or problem would not have been observable among the 41 recovered fatalities. That percentage probability declines to 0.59 per cent when 2 of the lost ejectees are assumed to have sustained such injuries or problems, 0.035 per cent for 3, and 0.0016 per cent for 4. Such probability examinations, of course, do not address the potential that a lost ejectee or even a drowned ejectee may have sustained a transient injury such as unconsciousness and died as a consequence. That issue requires case-by-case reviews to ascertain as completely as possible the condition of the lost ejectee following surface contact and to compare that condition for ejectees using highly similar seats under similar conditions.

The issue as to whether ejection should be accomplished through-the-canopy or only after the canopy has been jettisoned often has been an emotional one in which proponents of a particular view seldom acknowledge that there might exist valid arguments for the opposing view. What advantages are gained by jettisoning the canopy and what penalties are incurred? And, on the other side of the issue, what are the benefits and penalties associated with through-the-canopy ejection?

Jettisoning the canopy has for a considerable period resulted in a lowered vertebral fracture rate in comparison to that associated with through-the-canopy ejection. For example, among otherwise comparable Mk5 series ejection seats, the jettisoned-canopy ejection vertebral fracture rate was less than one-fifth (1/5) that associated with through-the-canopy ejections.

Film data from many ejection seat tests and recent clear G_z traces (Figures 1 and 2) have repeatedly shown that during a through-the-canopy ejection (Figure 3), the seat rises abruptly until contacting the canopy. Following canopy contact, the seat rapidly decelerates while the canopy yields. After the canopy yields sufficiently to break, the seat rapidly reaccelerates influenced by higher catapult gas pressures and, often, an effectively reduced ejected mass. The reduction in the effective ejected mass is caused by the seat occupant tendency to rise off the seat into the harness as the seat is slowed during contact with the canopy. If in fact the occupant does achieve separation from the seat pan, the occupant then is subjected to a serious seat slap when the reaccelerating seat reestablishes contact after canopy breakthrough. That seat slap can readily exceed human spine G_z tolerance levels.

Observations during tests, test films and in-service ejection data clearly suggest that canopy jettisoning before ejection results in a lower incidence of lacerations, punctures, contusions, and hematoma. Such data indicate also a lowered incidence of damage to flight and survival protective equipments worn by the ejectee. Two mechanisms appear to be working to produce injury and equipment damage during through-the-canopy ejections. Both involve ejectee and/or ejectee worn equipment contact with broken canopy glass. In one instance, free glass either remains in the path of the upward moving ejectee or the free glass is propelled by windblast into the ejectee's path. In the other, the ejectee contacts jagged break edges of the hole in the canopy as the seat propels the ejectee upward through the canopy.

Jettisoning the canopy eliminates, then, seat-canopy impact forces during the catapult boost forces and removes from the ejectee's path the canopy glass thereby eliminating the potential for glass induced injury and/or equipment damage.

From the aircraft designer's viewpoint, canopy jettisoning requires incorporation of a canopy thruster and requires strengthening part of the canopy to accept the thrust loads and strengthening airframe structure to react those thrust loads. Such a system adds weight with its attendant impact upon aircraft weight and balance and aircraft performance. In addition, such a system adds some cost both to the development/production end and to the cost of ownership.

From the viewpoint of the escape system designer, canopy jettisoning is another system failure point with the potential for reducing escape system reliability. Canopy jettisoning makes the escape system more complex, frequently inviting more maintenance type and/or localized aircraft damage type problems since a signal must be transmitted from the seat to the aircraft mounted canopy jettisoning system, the canopy unlocking mechanism must be actuated, the canopy jettisoning system must be initiated, and a signal then must be transmitted back to the seat to initiate the catapult boost. In the eleven year period from 1 January 1969 through 31 December 1979, thirty-five individuals were reported as having attempted ejection which was not accomplished (Type 3 Ejection). Thirty-two of thse involved jettisoned-canopy systems and three through-the-canopy systems. The overwhelming preponderance of the problems results in the non-ejection were associated with the added complexity of the canopy jettisoning system and its interface. In addition, there was one ejection classified as "accomplished, not clear of aircraft" (Type 2 Ejection) involving a failure of a canopy jettisoned clear signal to actuate seat ejection.

In several escapes, jettisoned canopies have actually interfered with egress or subsequent operation of the escape system after having signalled the seat to eject. The circumstances have involved canopy jettisoning during decelerations induced by an aircraft sliding on the ground (canopy opened sufficiently to trigger catapult initiation, then pivoted forward striking the back of the rising seat deflecting it into a forward, very low trajectory insufficiently high for parachute deployment and opening prior to ejectee ground impact) and canopy jettisonings from aircraft in spin or other types of uncontrolled flight in which canopies on several occasions remained hovering above the aircraft in a location close to, or interfering with, the man-seat trajectory.

In earlier years large canopies for two-place aircraft when jettisoned during spins occasionally rotated about their longitudinal axis while rising, injuring, sometimes fatally, rear seat crewmen. Efforts to preclude this problem have added weight and complexity to aircraft and impacted program schedules and costs.

Jettisoning canopies requires time during which, if the aircraft is descending and/or rolling or pitching inverted, the escape capabilities of the ejection seat may be exceeded. The attached table and the single associated figure (Figure 4) on which the data for 200kts. airspeed is plotted provide information concerning altitude loss as a function of time delay (e.g., incurred during canopy jettisoning or other function) and aircraft actual flight path angle with the horizon.

Figures 5 and 6 depict ways in which canopy jettisoning type and through-the-canopy type ejections, respectively, can result in fatalities. Figures 7 and 8 depict ways partial-cutting-canopy type and total-canopy-fragmentation type ejections, respectively, can result in fatalities. Each tree includes a portion depicting fatality causes not related to canopy mode and a portion for fatality causes related to canopy mode. Figures 5 and 8 are currently in preliminary stages of development. Figure 9 provides a comparison of the sequences of events complexities for each of these ejection associated canopy modes.

The point to be kept in mind, therefore, is that there are benefits and penalties, both, associated with each of the canopy modes used to date. None of the newer approaches yet advanced to resolve the canopy problems affords a no penalty approach. Each offers advantages and each carries with it penalties and comparative evaluations are difficult; in large part due to the absence of carefully analyzed in-service escape data.

VERTEBRAL COMPRESSION FRACTURE MECHANISMS

THROUGH-THE-CANOPY EJECTION

Produces multiphasic abrupt changes in ejectee accelertions and resulting forces imposed upon vertebrae:

o INITIAL BOOST PHASE
- initial body loading, body elements shift downward
- due to body's "mass-spring-damper system" characteristics
  body segment velocities are nonuniform
  body segment velocities lower than seat velocity

o SEAT-CANOPY IMPACT PHASE
- seat decelerates rapidly
- body segments tend to continue at unchanging velocity

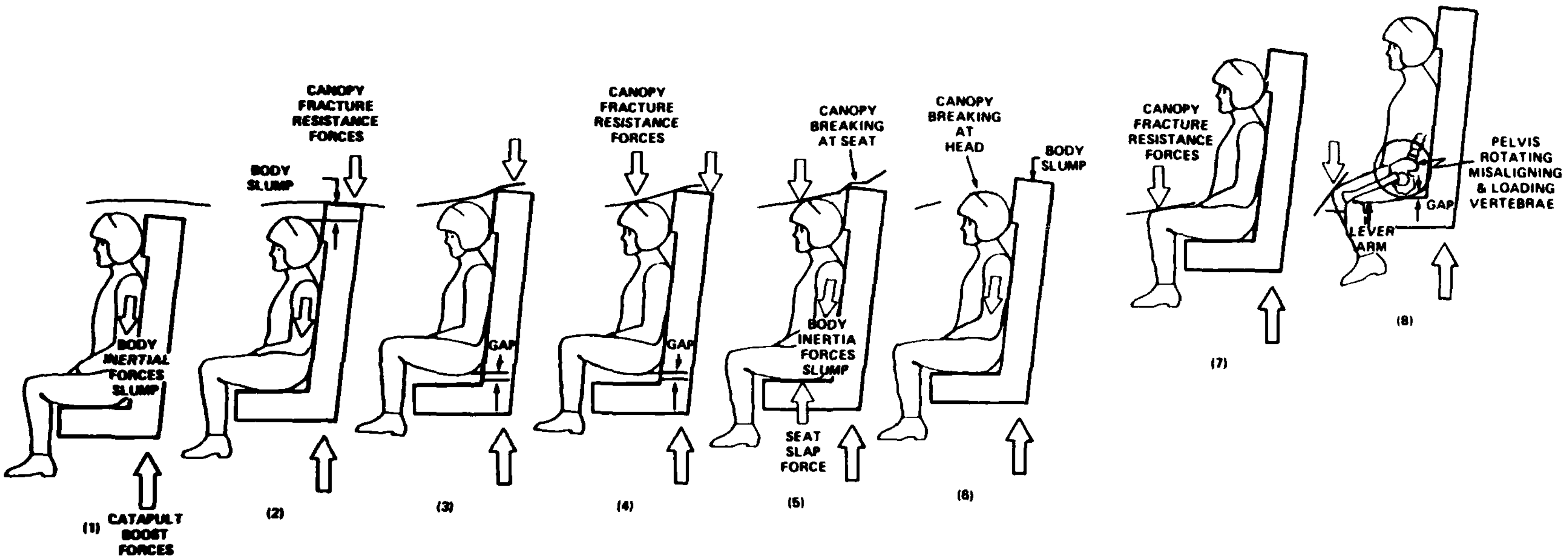
o CANOPY YIELDING PHASE
- seat movement small
  seat velocity decreasing rapidly
  catapult internal pressures rising rapidly
- body shifts upward within seat and velocities decrease
  reduces buttock and vertebral loading
  body loads shoulder harness/shoulder girdle
    possibly reversing vertebral loading
  head contacts canopy
    possibly reversing vertebral loading
    possibly inducing vertebral misalignment

o CANOPY PENETRATION PHASE
- seat accelerates rapidly due to:
  higher catapult internal pressures
  effective reduced ejected weight (temporary man-seat separation during canopy yielding phase)
- seat moves upward relative to body
  seat movement may induce "overshoot" acceleration in body
  body movement may be temporarily retarded by canopy contact with head
    exacerbating vertebral loading
    exacerbating vertebral misalignment

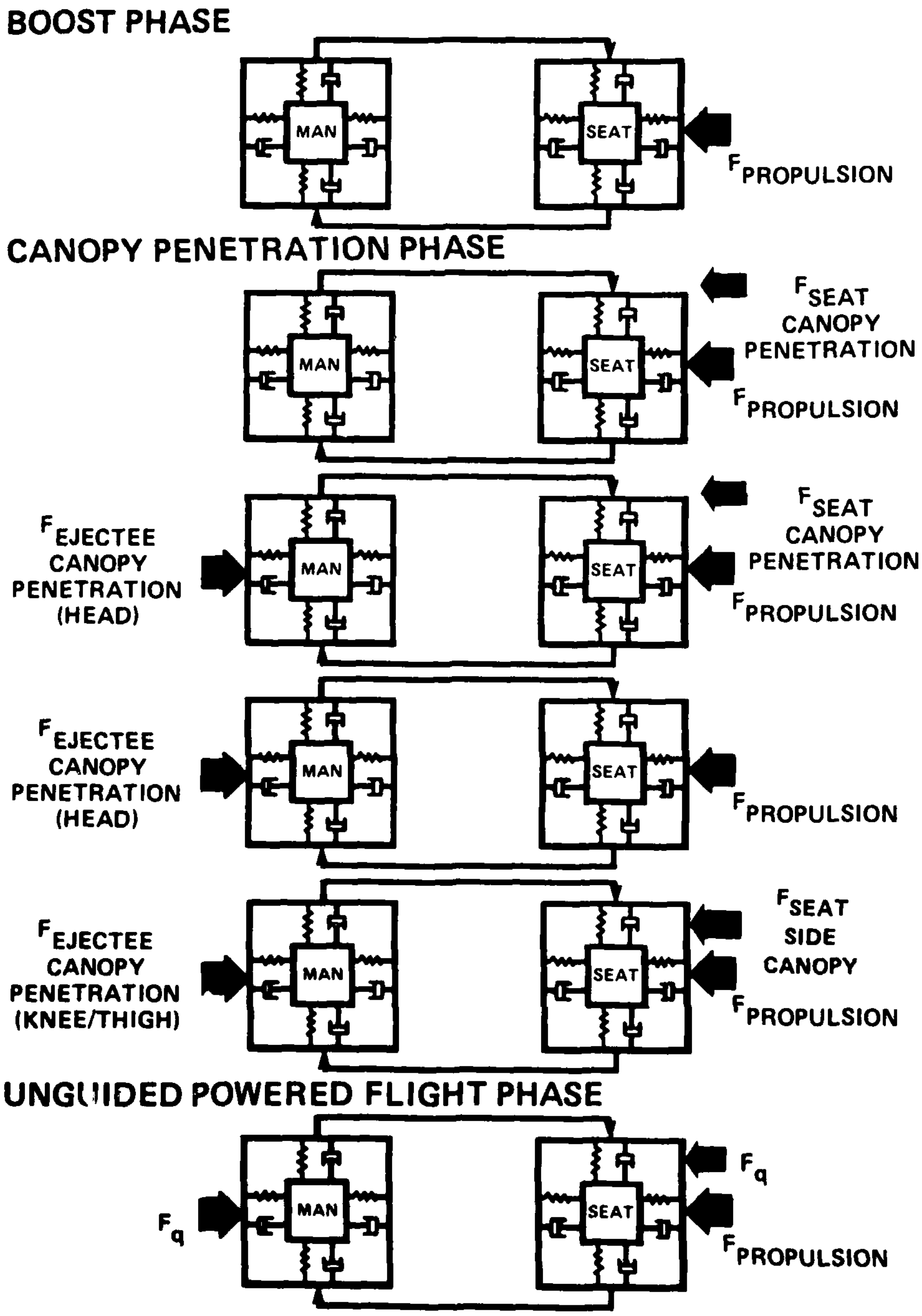
o SEAT CLEAR PHASE

CHART 1

GENERALIZED CONCEPTUALIZATION OF BODY MOTIONS AND FORCES ASSOCIATED WITH THROUGH-THE-CANOPY EJECTION (GOOD RESTRAINT/POSTURE)

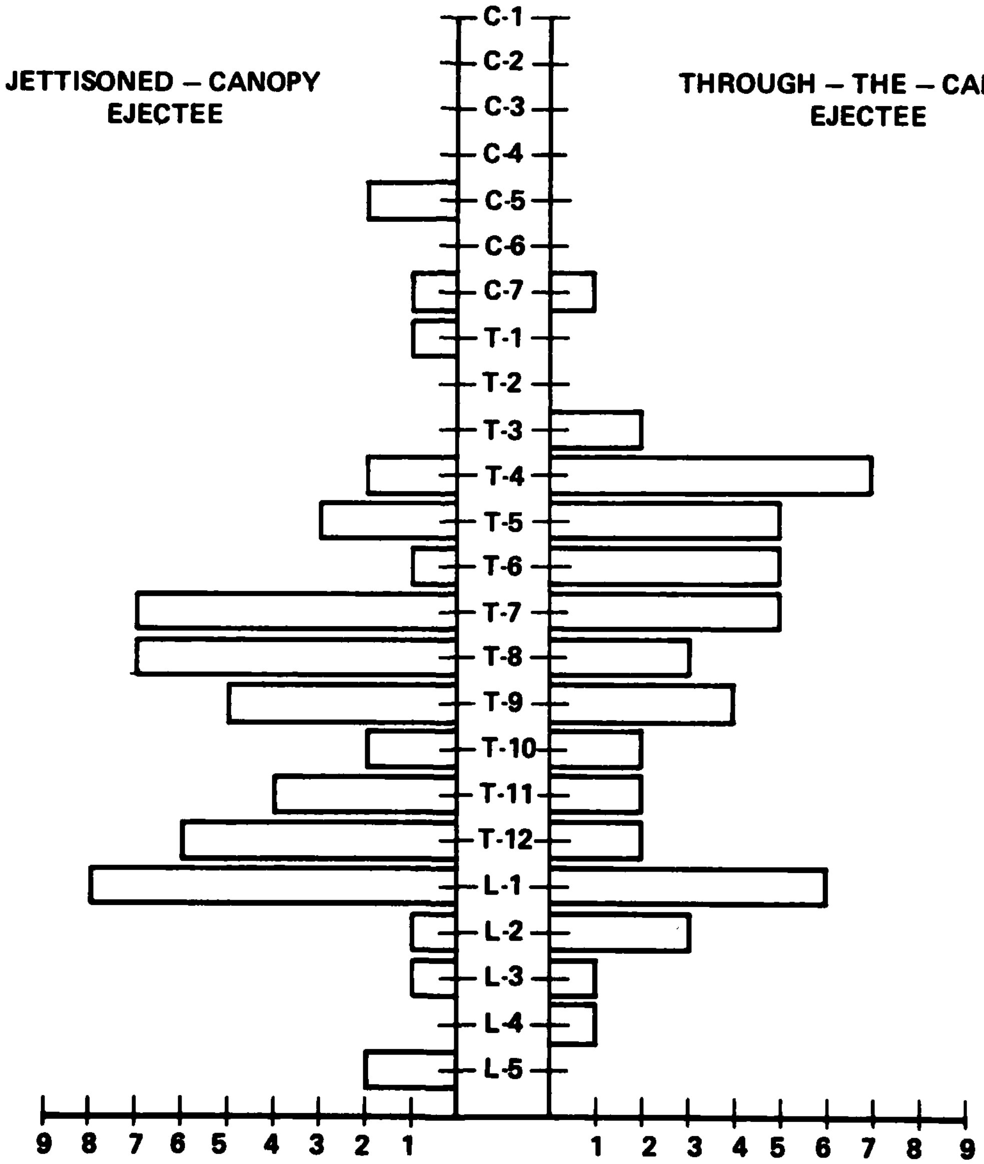


GENERALIZED CONCEPTUALIZATION OF MAN-SEAT INTERACTIONS AND EXTERNAL FORCES OPERATING ON COMBINATION



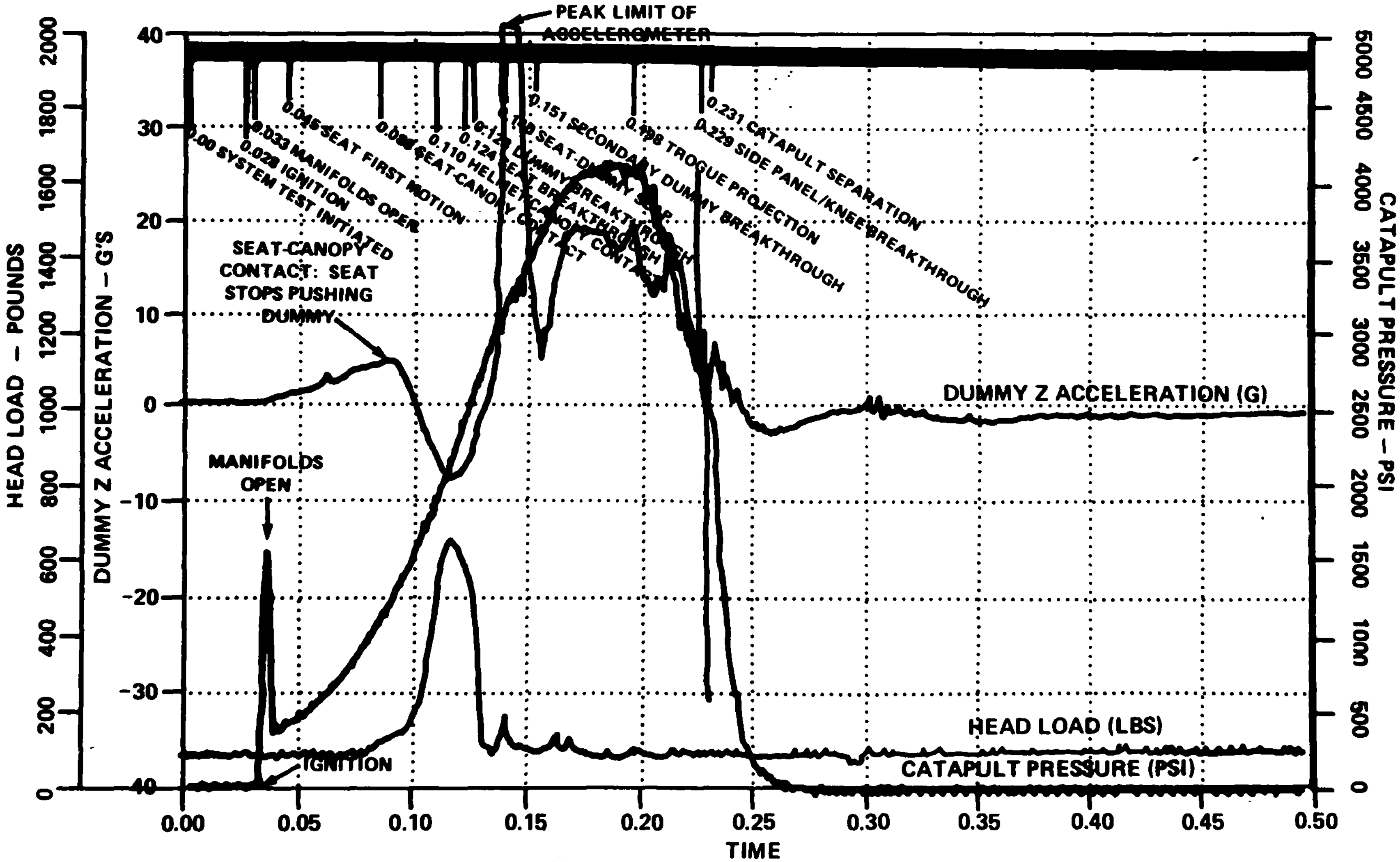
NUMBERS OF COMPRESSIONS FRACTURES REPORTED

COMPARISON OF COMPRESSION FRACTURE FREQUENCY AMONG VERTEBRAE FOR JETTISONED–CANOPY AND THROUGH–THE–CANOPY USN EJECTEES FOR PERIOD 1/1/69 THROUGH 12/1/79



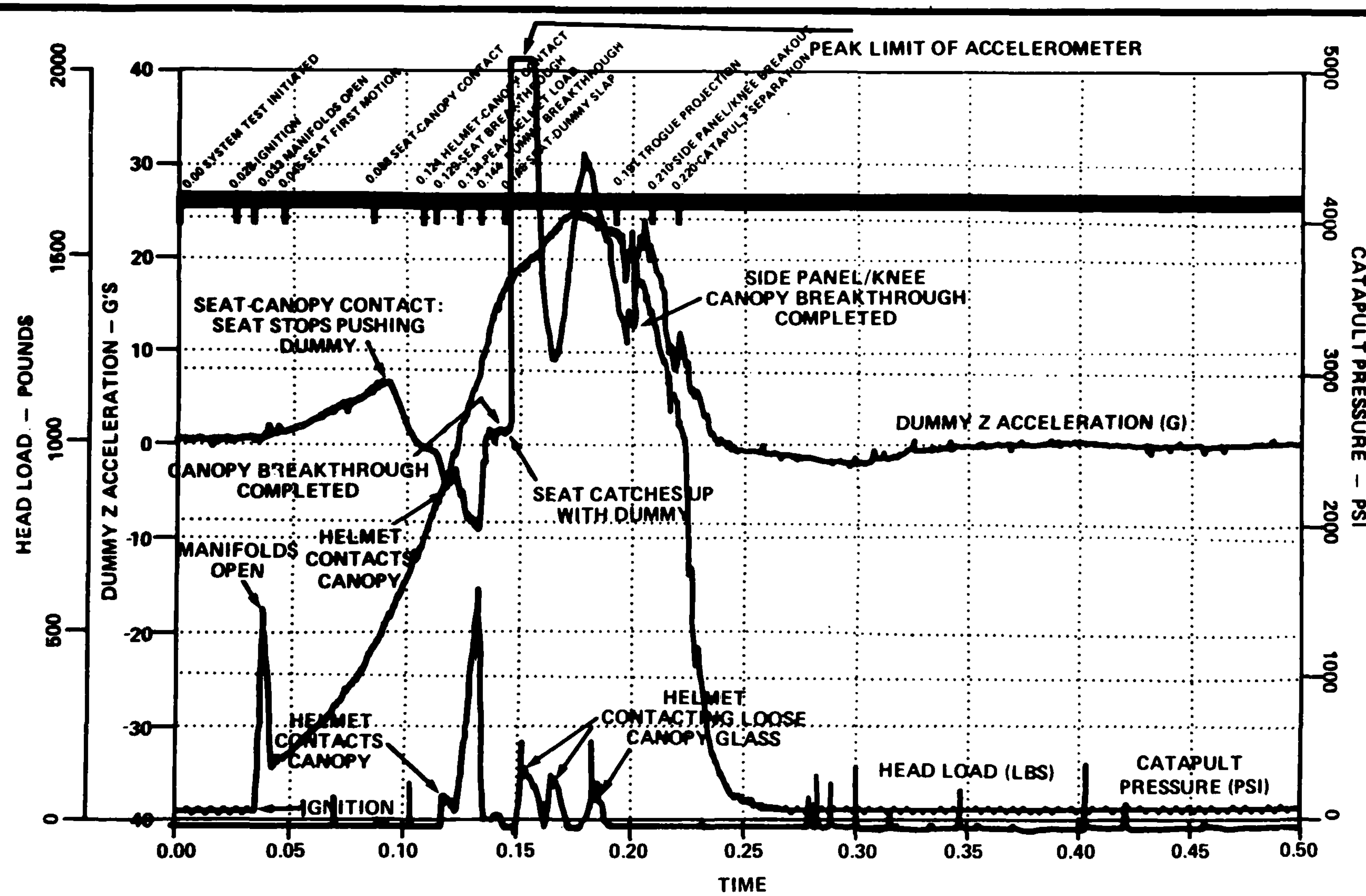
98TH PERCENTILE EVENT TIME LINE

CANOPY PENETRATION(O/O)
A7, RUN 2, TEST T-1301
TEST DATE 23 OCTOBER 1980



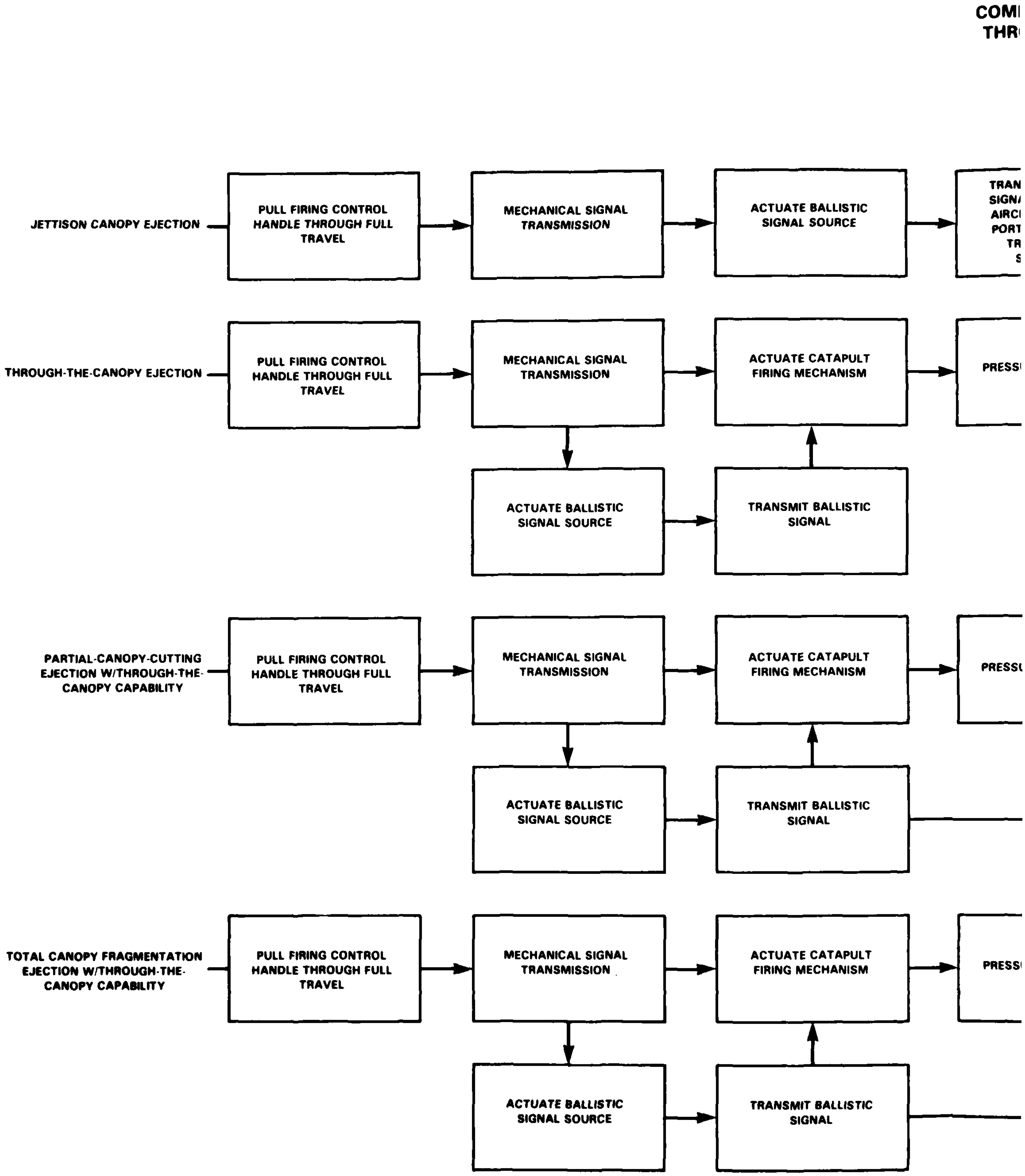
3RD PERCENTILE EVENT TIME LINE

CANOPY PENETRATION
A7, RUN 1, TEST T-1301
TEST DATE 22 OCTOBER 1980



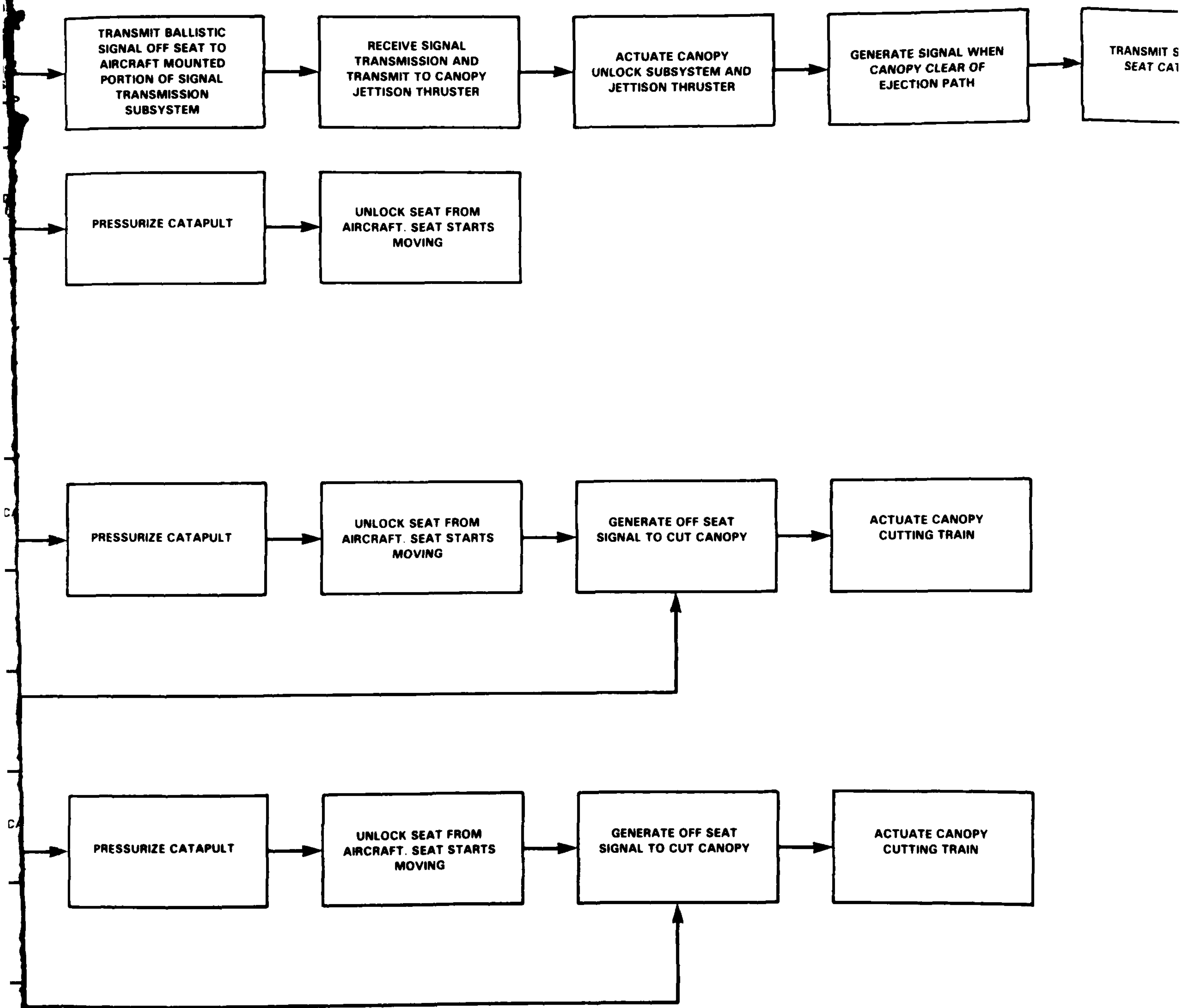
AIRCRAFT ALTITUDE LOSS OCCURRING DURING DELAYS VERSUS AIRCRAFT AIRSPEED AND FLIGHT PATH ANGLE

AIRSPEED AT EJECTION (KNOTS)	FLIGHT PATH AT EJECTION (DEGREES NOSE DOWN)	AIRCRAFT VELOCITIES (FEET PER SECOND)			AIRCRAFT ALTITUDE LOSS BETWEEN ESCAPE INITIATION AND DELAYED EVENT OCCURRENCE (FEET)													
		FLIGHT PATH	VERTICAL DESCENT	HORIZONTAL	0.10 SEC	0.12 SEC	0.15 SEC	0.30 SEC	0.40 SEC	0.50 SEC	0.60 SEC	0.75 SEC	1.00 SEC	1.25 SEC	1.50 SEC	2.00 SEC	2.50 SEC	2.65 SEC
100	5°	168.89	14.72	168.25	1.47	1.77	2.21	4.42	5.89	7.36	8.83	11.04	14.72	18.40	22.08	29.44	36.80	39.01
	10°		29.33	166.32	2.93	3.52	4.40	8.80	11.73	14.66	17.60	22.00	29.33	36.66	43.99	58.65	73.32	77.72
	30°		84.44	146.26	8.44	10.13	12.67	25.33	33.78	42.22	50.67	63.33	84.44	105.56	126.67	168.89	211.11	223.78
	45°		119.42	119.42	11.94	14.33	17.91	35.83	47.77	59.71	71.65	89.57	119.42	149.28	179.13	238.85	298.56	316.47
	60°		146.26	84.44	14.63	17.55	21.94	43.88	58.50	73.13	87.76	109.70	146.26	182.83	219.39	292.52	365.66	387.59
	75°		163.13	43.71	16.31	19.58	24.47	48.94	65.25	81.57	97.88	122.35	163.13	203.92	244.70	326.27	407.84	432.31
	90°		168.89	0	16.89	20.27	25.33	50.67	67.56	84.44	101.33	126.67	168.89	211.11	253.33	337.78	422.22	447.56
200	5°	337.78	29.44	336.49	2.94	3.53	4.42	8.83	11.78	14.72	17.66	22.08	29.44	36.80	44.16	58.88	73.60	78.01
	10°		58.66	332.65	5.87	7.04	8.80	17.60	23.46	29.33	35.19	43.99	58.65	73.32	87.98	117.31	146.64	155.43
	30°		168.89	292.52	16.89	20.27	25.33	50.67	67.56	84.44	101.33	126.67	168.89	211.11	253.33	337.78	422.22	447.56
	45°		238.85	238.85	23.89	28.66	35.83	71.65	95.54	119.42	143.31	179.13	238.85	298.56	358.27	477.69	597.11	632.94
	60°		292.52	168.89	29.26	35.10	43.88	87.76	117.01	146.26	175.51	219.39	292.52	365.66	438.79	585.05	731.31	775.19
	75°		326.27	87.42	32.63	39.15	48.94	97.88	130.51	163.13	195.76	244.70	326.27	407.84	489.40	652.54	815.67	864.61
	90°		337.78	0	33.78	40.53	50.67	101.33	135.11	168.89	202.67	253.33	337.78	422.22	506.67	675.56	844.44	895.11
300	5°	506.67	44.16	504.74	4.42	5.30	6.62	13.25	17.66	22.08	26.50	33.12	44.16	55.20	66.24	88.32	110.40	117.02
	10°		87.98	498.97	8.80	10.56	13.20	26.39	35.19	43.99	52.79	65.99	87.98	109.98	131.97	175.96	219.95	233.15
	30°		253.33	438.79	25.33	30.40	38.00	76.00	101.33	126.67	152.00	190.00	253.33	316.67	380.00	506.67	633.33	671.33
	45°		358.27	358.27	35.83	42.99	53.74	107.48	143.31	179.13	214.97	268.70	358.27	447.83	537.40	716.53	895.67	949.41
	60°		438.79	253.33	43.88	52.65	65.82	131.64	175.51	219.39	263.27	329.09	438.79	548.48	658.18	877.57	1096.97	1162.78
	75°		489.40	131.14	48.94	58.73	73.41	146.82	195.76	244.70	293.64	367.05	489.40	611.75	734.10	978.80	1223.51	1296.92
	90°		506.67	0	50.67	60.80	76.00	152.00	202.67	253.33	304.00	380.00	506.67	633.33	760.00	1013.33	1266.67	1342.67
400	5°	675.56	58.88	672.98	5.89	7.07	8.83	17.66	23.55	29.44	35.33	44.16	58.88	73.60	88.32	117.76	147.20	156.03
	10°		117.31	665.29	11.73	14.08	17.60	35.19	46.92	58.65	70.39	87.98	117.31	146.64	175.96	234.62	293.27	310.87
	30°		337.78	585.05	33.78	40.53	50.67	101.33	135.11	168.89	202.67	253.33	337.78	422.22	506.67	675.56	844.44	895.11
	45°		477.69	477.69	47.77	57.32	71.65	143.31	191.08	238.85	286.61	358.27	477.69	597.11	617.53	955.38	1194.22	1265.88
	60°		585.05	337.78	58.51	70.21	87.76	175.51	234.02	292.52	351.03	438.79	585.05	732.56	877.57	1170.10	1462.62	1550.38
	75°		652.54	174.85	65.25	78.30	97.88	195.76	261.01	326.27	391.52	489.40	652.54	816.67	978.80	1305.07	1631.34	1729.22
	90°		675.56	0	67.56	81.07	101.33	202.67	270.22	337.78	405.33	506.67	675.56	844.44	1013.33	1351.11	1688.89	1790.22
500	5°	844.44	73.60	841.23	7.36	8.83	11.04	22.08	29.44	36.80	44.16	55.20	73.60	92.00	110.40	147.20	184.00	195.04
	10°		146.64	831.62	14.66	17.60	22.00	43.99	58.65	73.32	87.98	109.98	146.64	183.30	219.96	293.27	366.59	388.59
	30°		422.22	731.31	42.22	50.67	63.33	126.67	168.89	211.11	253.33	316.67	422.22	527.78	633.33	844.44	1055.56	1118.89
	45°		597.11	597.11	59.71	71.65	89.57	179.13	238.85	298.56	358.27	447.83	597.11	746.39	895.67	1194.22	1492.78	1582.35
	60°		731.31	422.22	73.13	87.76	109.70	219.39	292.52	365.66	438.79	548.48	731.31	914.14	1096.97	1462.62	1828.28	1937.97
	75°		815.67	218.56	81.57	97.88	122.35	244.70	326.27	407.84	489.40	611.75	815.67	1019.59	1223.51	1631.34	2039.18	2161.53
	90°		844.44	0	84.44	101.33	126.67	253.33	337.78	422.22	506.67	633.33	844.44	1055.56	1266.67	1688.89	2111.11	2237.78
600	5°	1013.33	88.32	1009.48	8.83	10.60	13.25	26.50	35.33	44.16	52.99	66.24	88.32	110.40	132.48	176.64	220.79	234.04
	10°		175.97	997.94	17.60	21.12	26.39	52.79	70.39	87.98	105.58	131.97	175.96	219.95	263.95	351.93	439.91	466.30
	30°		506.67	877.57	50.67	60.80	76.00	152.00	202.67	253.33	304.00	380.00	506.67	633.33	760.00	1013.33	1266.67	1342.67
	45°		716.53	716.53	71.65	85.98	107.48	214.96	286.61	358.27	429.92	537.40	716.53	895.67	1074.80	1433.07	1791.34	1898.82
	60°		877.57	506.67	87.76	105.31	131.64	263.27	351.03	438.79	526.54	658.18	877.57	1096.97	1316.36	1755.14	2193.93	2325.57
	75°		978.80	262.27	97.88	117.46	146.82	293.64	391.52	489.40	587.28	734.10	978.80	1223.51	1468.21	1957.61	2447.01	2593.83
	90°		1013.33	0	101.33	121.60	152.00	304.00	405.33	506.67	608.00	760.00	1013.33	1266.67	1620.00	2026.67	2533.33	2685.33

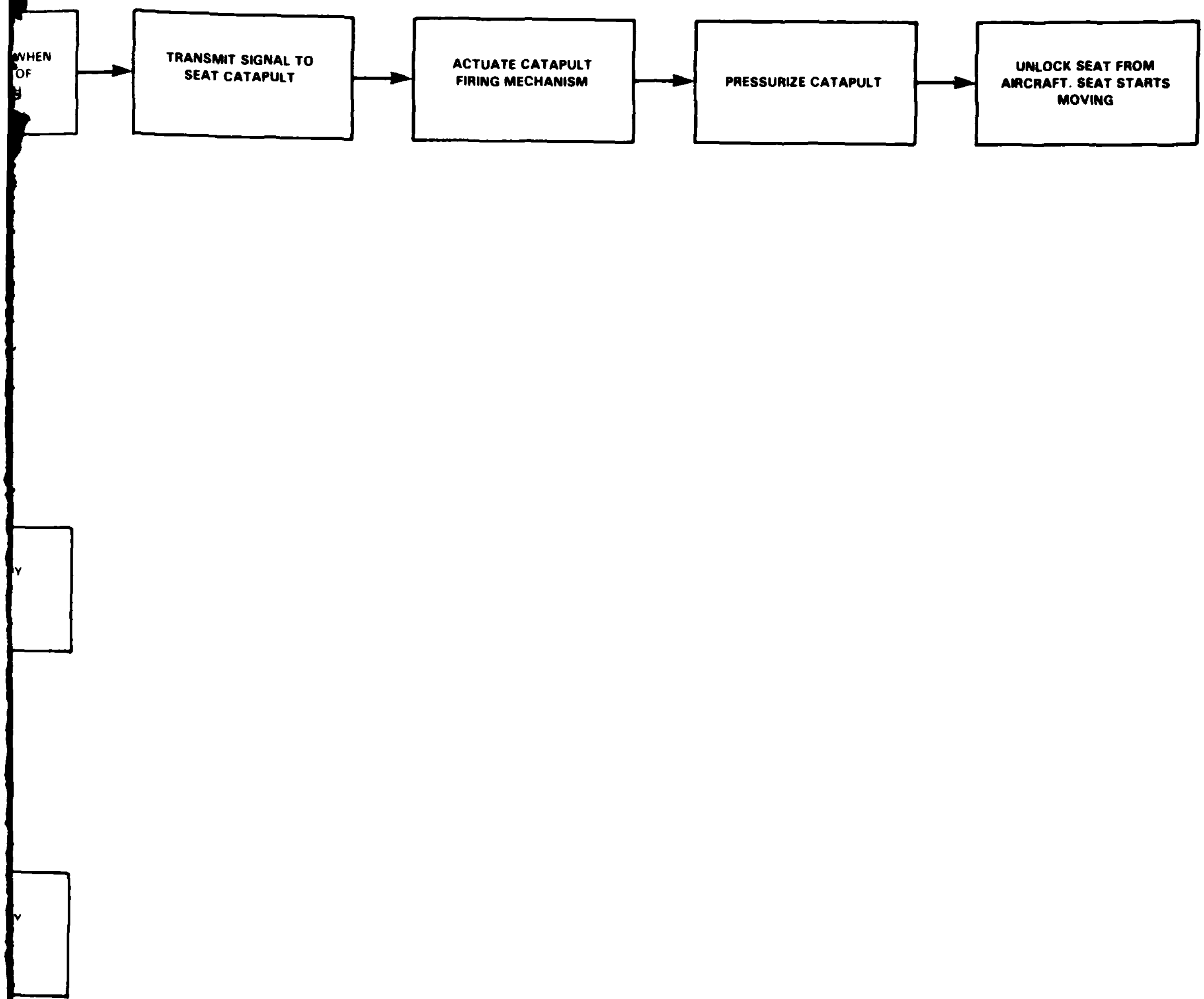

JETTISON CANOPY EJECTION
PULL FIRING CONTROL HANDLE THROUGH FULL TRAVEL
MECHANICAL SIGNAL TRANSMISSION
ACTUATE BALLISTIC SIGNAL SOURCE
THROUGH-THE-CANOPY EJECTION
PULL FIRING CONTROL HANDLE THROUGH FULL TRAVEL
MECHANICAL SIGNAL TRANSMISSION
ACTUATE CATAPULT FIRING MECHANISM
ACTUATE BALLISTIC SIGNAL SOURCE
TRANSMIT BALLISTIC SIGNAL
PARTIAL-CANOPY-CUTTING EJECTION W/THROUGH-THE-CANOPY CAPABILITY
PULL FIRING CONTROL HANDLE THROUGH FULL TRAVEL
MECHANICAL SIGNAL TRANSMISSION
ACTUATE CATAPULT FIRING MECHANISM
ACTUATE BALLISTIC SIGNAL SOURCE
TRANSMIT BALLISTIC SIGNAL
TOTAL CANOPY FRAGMENTATION EJECTION W/THROUGH-THE-CANOPY CAPABILITY
PULL FIRING CONTROL HANDLE THROUGH FULL TRAVEL
MECHANICAL SIGNAL TRANSMISSION
ACTUATE CATAPULT FIRING MECHANISM
ACTUATE BALLISTIC SIGNAL SOURCE
TRANSMIT BALLISTIC SIGNAL

(1)

COMPARATIVE EVENT SEQUENCE TRAIN COMPLEXITIES FOR EFFECTING JETTISONED-CANOPY, THROUGH-THE-CANOPY, PARTIAL-CANOPY-CUTTING, AND TOTAL-CANOPY-FRAGMENTATION EJECTIONS



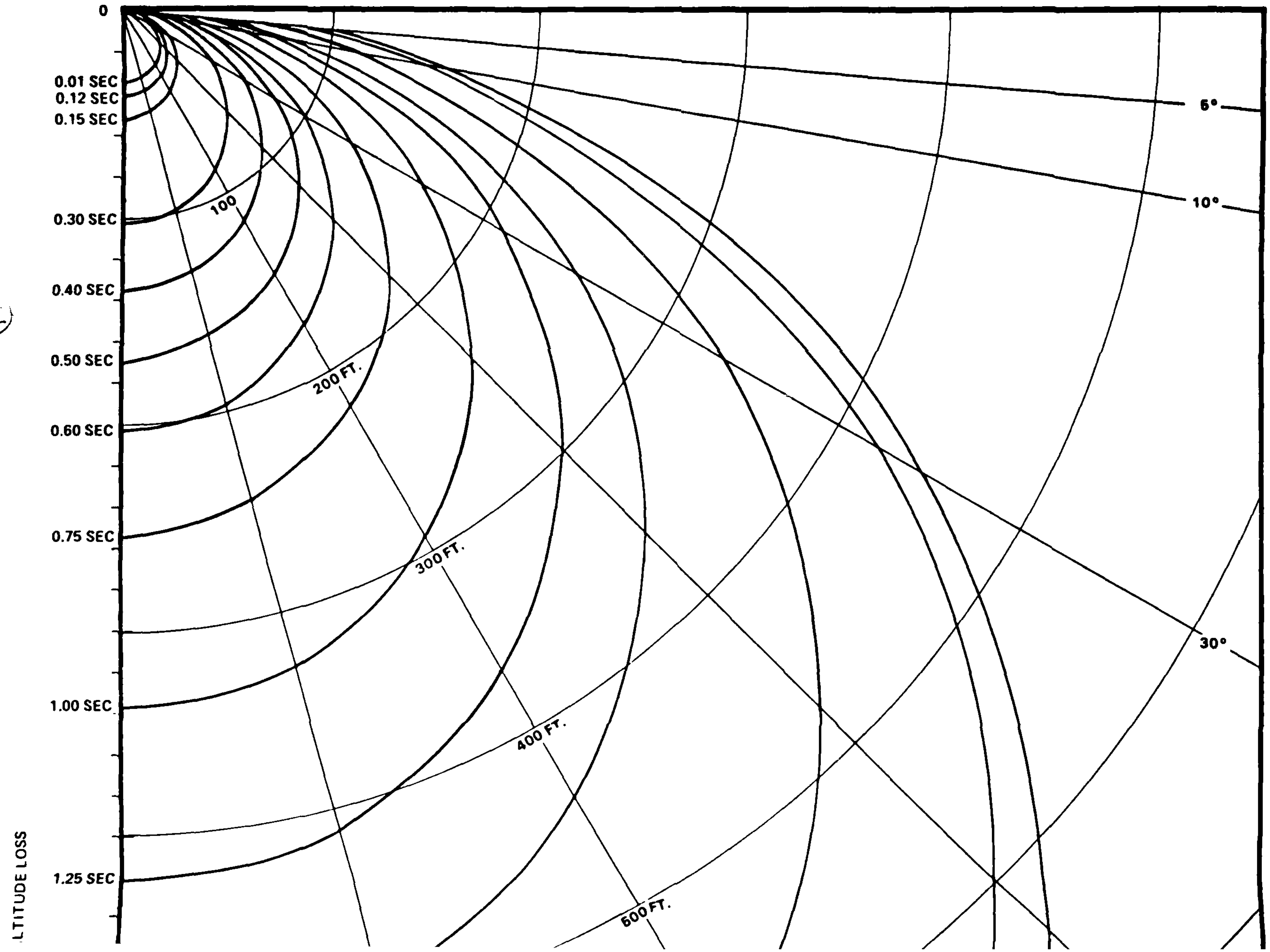
2

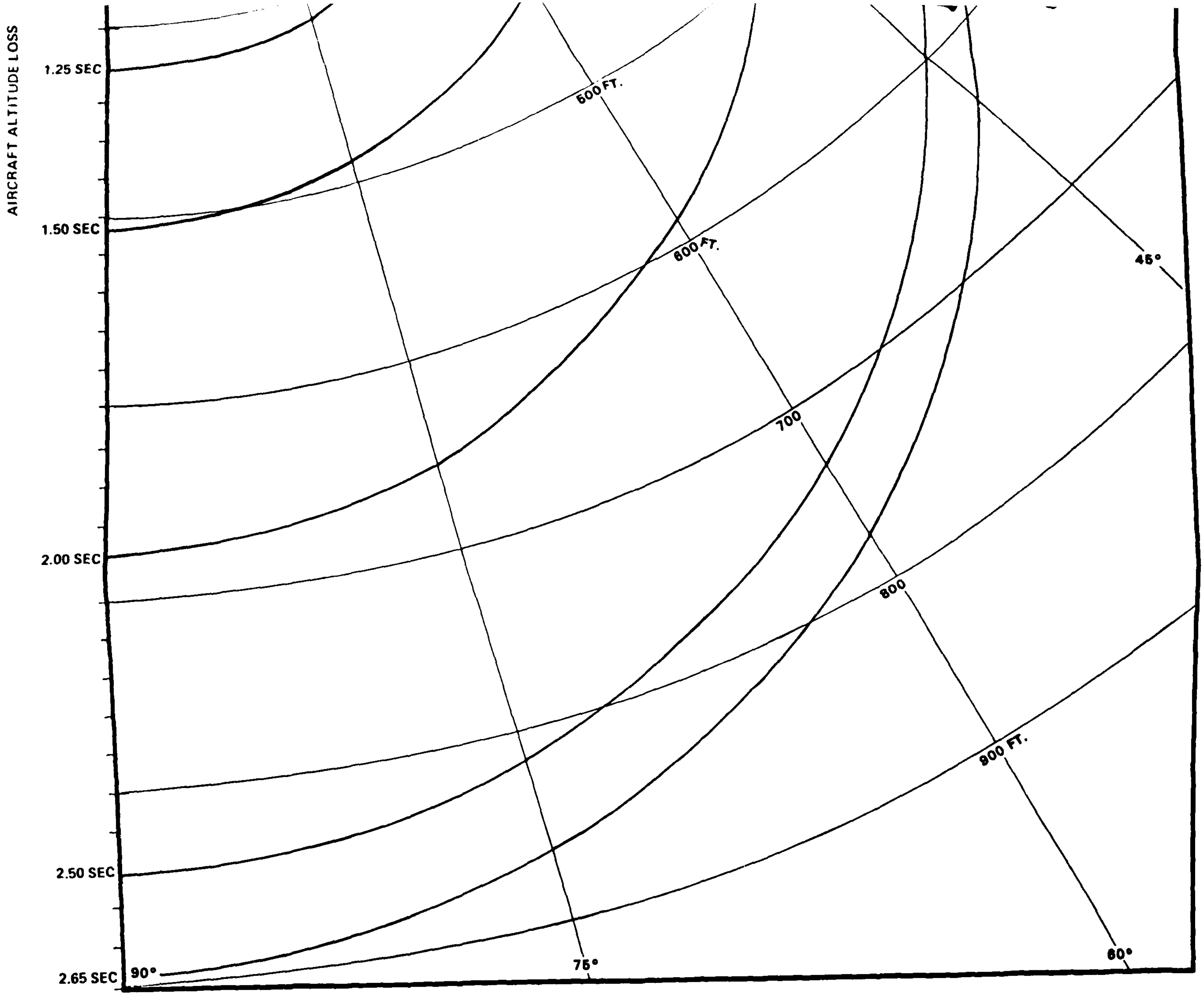


WHEN
OF
TRANSMIT SIGNAL TO SEAT CATAPULT
ACTUATE CATAPULT FIRING MECHANISM
PRESSURIZE CATAPULT
UNLOCK SEAT FROM AIRCRAFT. SEAT STARTS MOVING

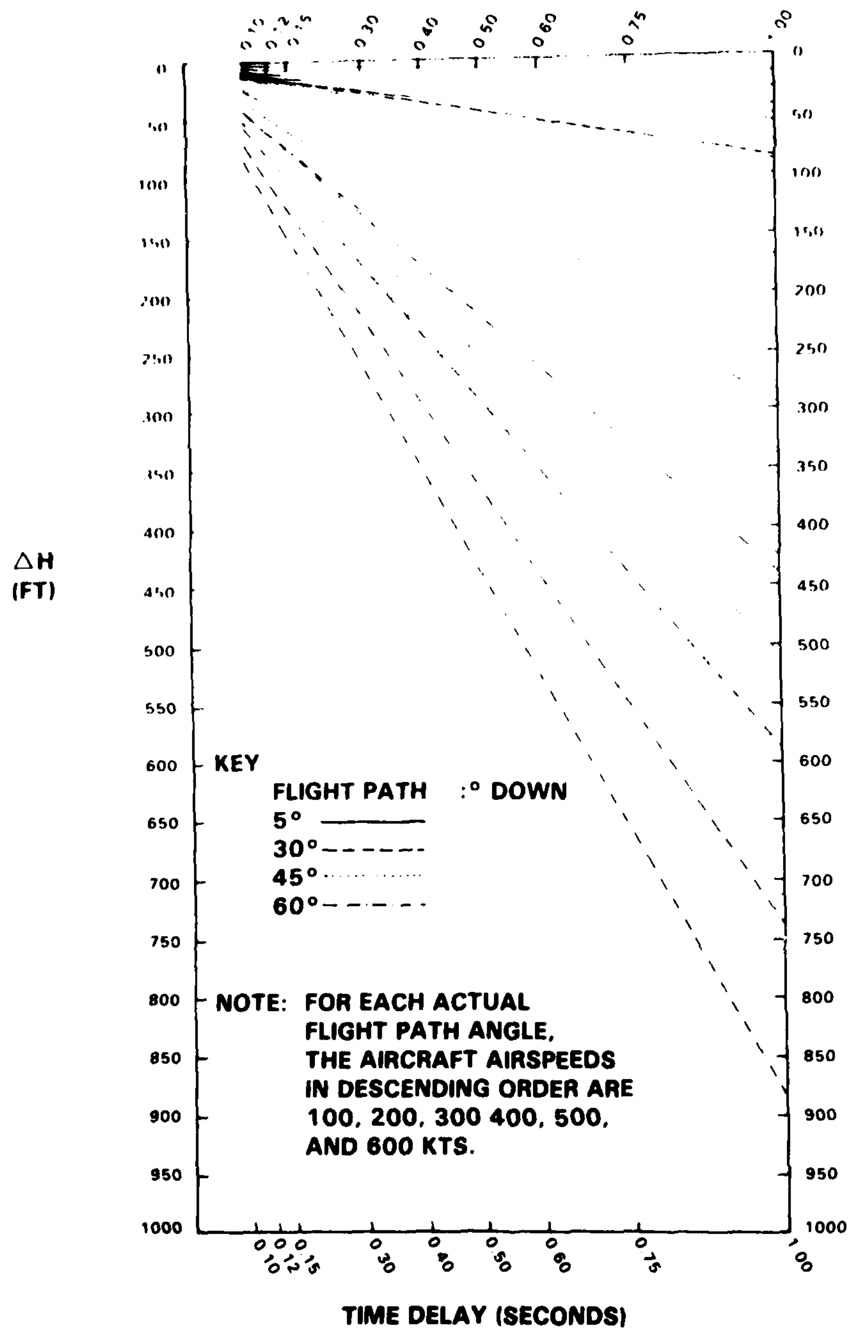
(3)

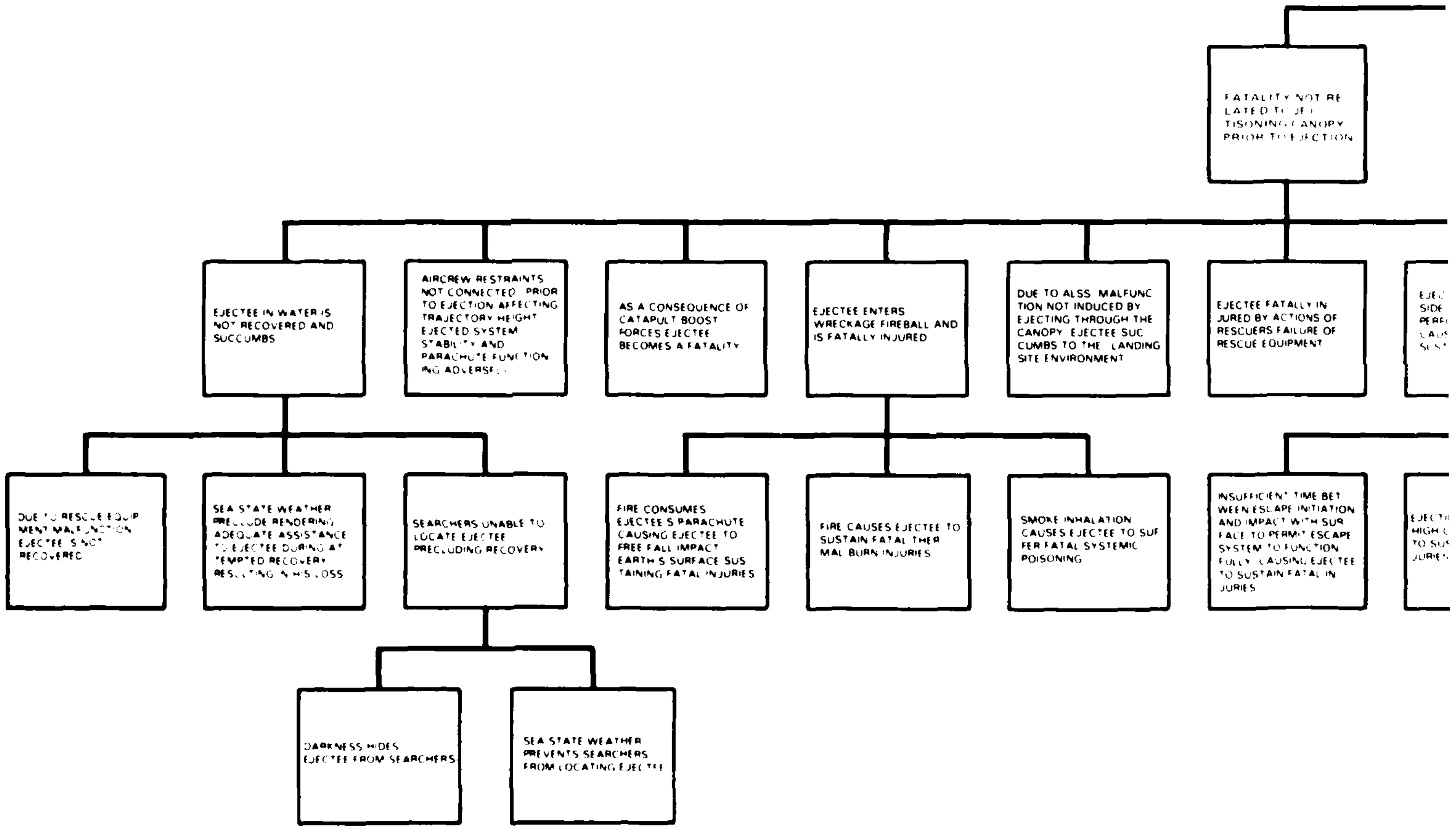
AIRCRAFT ALTITUDE LOSS OCCURRING DURING DELAYS VERSUS AIRCRAFT
AIRSPEED @ 200 KTS AND FLIGHT PATH ANGLE




AIRCRAFT ALTITUDE LOSS
1.25 SEC
1.50 SEC
2.00 SEC
2.50 SEC
2.65 SEC
500 FT.
600 FT.
700
800
900 FT.
45°
60°
75°
90°

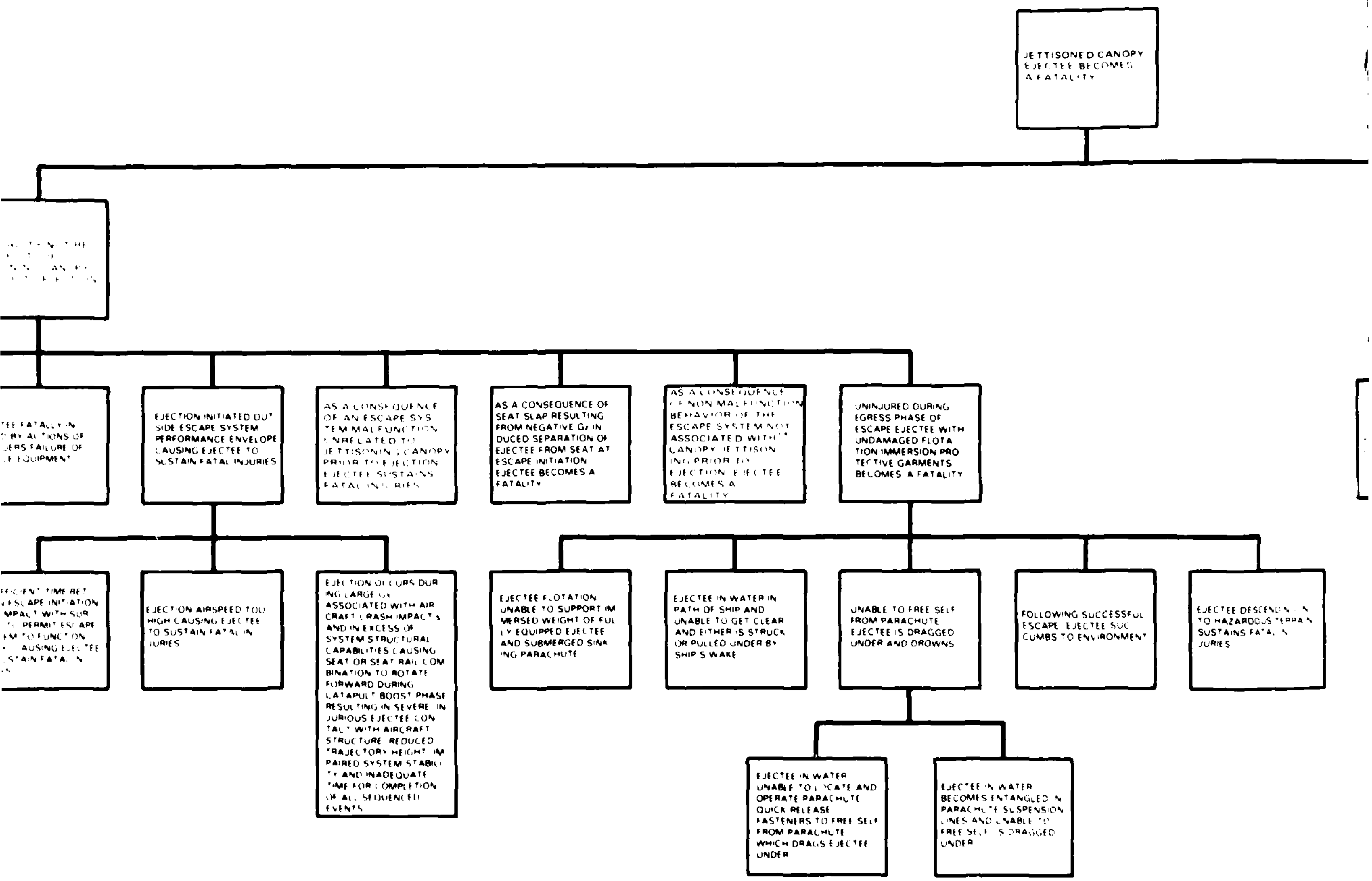
ALTITUDE LOSS AS A FUNCTION OF AIRCRAFT ACTUAL FLIGHT PATH (° DOWN) AND AIRSPEED



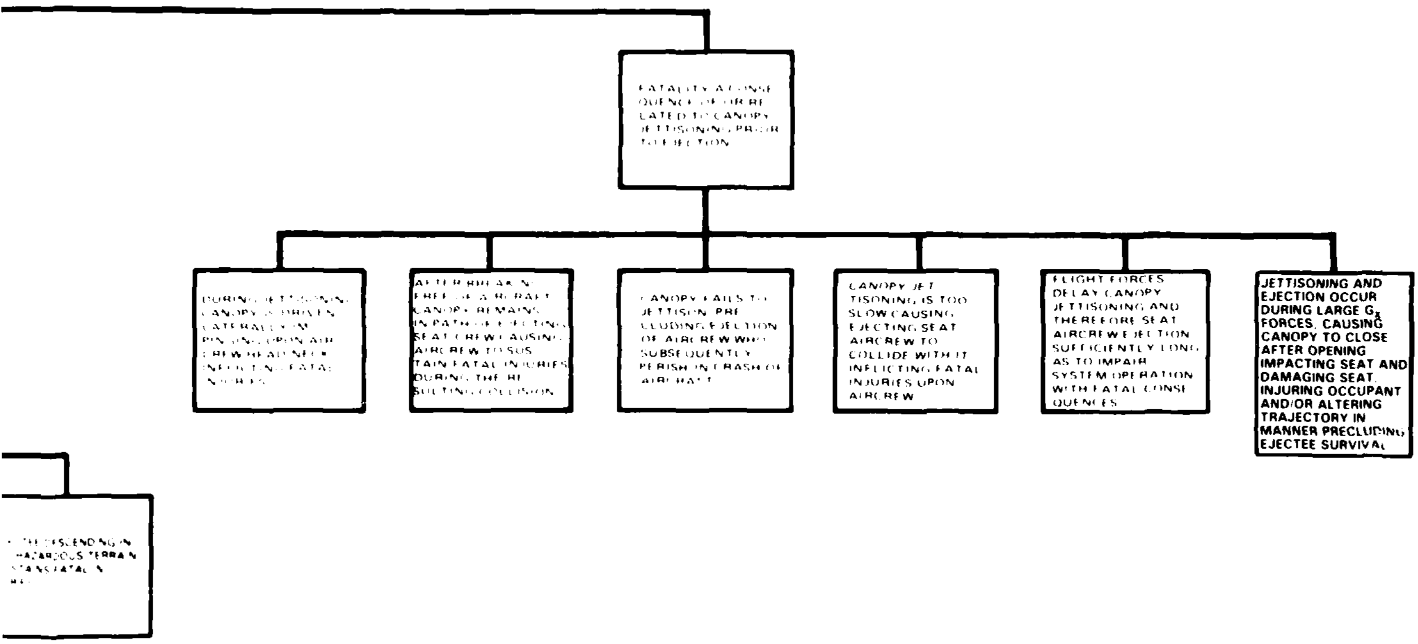

FATALITY NOT RELATED TO JETTISONING CANOPY PRIOR TO EJECTION
EJECTEE IN WATER IS NOT RECOVERED AND SUCCUMBS
AIRCREW RESTRAINTS NOT CONNECTED PRIOR TO EJECTION AFFECTING TRAJECTORY HEIGHT EJECTED SYSTEM STABILITY AND PARACHUTE FUNCTIONING ADVERSELY
AS A CONSEQUENCE OF CATAPULT BOOST FORCES EJECTEE BECOMES A FATALITY
EJECTEE ENTERS WRECKAGE FIREBALL AND IS FATALLY INJURED
DUE TO ALSS MALFUNCTION NOT INDUCED BY EJECTING THROUGH THE CANOPY EJECTEE SUCCUMBS TO THE LANDING SITE ENVIRONMENT
EJECTEE FATALLY INJURED BY ACTIONS OF RESCUERS FAILURE OF RESCUE EQUIPMENT
DUE TO RESCUE EQUIPMENT MALFUNCTION EJECTEE IS NOT RECOVERED
SEA STATE WEATHER PRECLUDE RENDERING ADEQUATE ASSISTANCE TO EJECTEE DURING ATTEMPTED RECOVERY RESULTING IN HIS LOSS
SEARCHERS UNABLE TO LOCATE EJECTEE PRECLUDING RECOVERY
FIRE CONSUMES EJECTEE S PARACHUTE CAUSING EJECTEE TO FREE FALL IMPACT EARTH S SURFACE SUSTAINING FATAL INJURIES
FIRE CAUSES EJECTEE TO SUSTAIN FATAL THERMAL BURN INJURIES
SMOKE INHALATION CAUSES EJECTEE TO SUFFER FATAL SYSTEMIC POISONING
INSUFFICIENT TIME BETWEEN ESCAPE INITIATION AND IMPACT WITH SURFACE TO PERMIT ESCAPE SYSTEM TO FUNCTION FULLY CAUSING EJECTEE TO SUSTAIN FATAL INJURIES
DARKNESS HIDES EJECTEE FROM SEARCHERS
SEA STATE WEATHER PREVENTS SEARCHERS FROM LOCATING EJECTEE

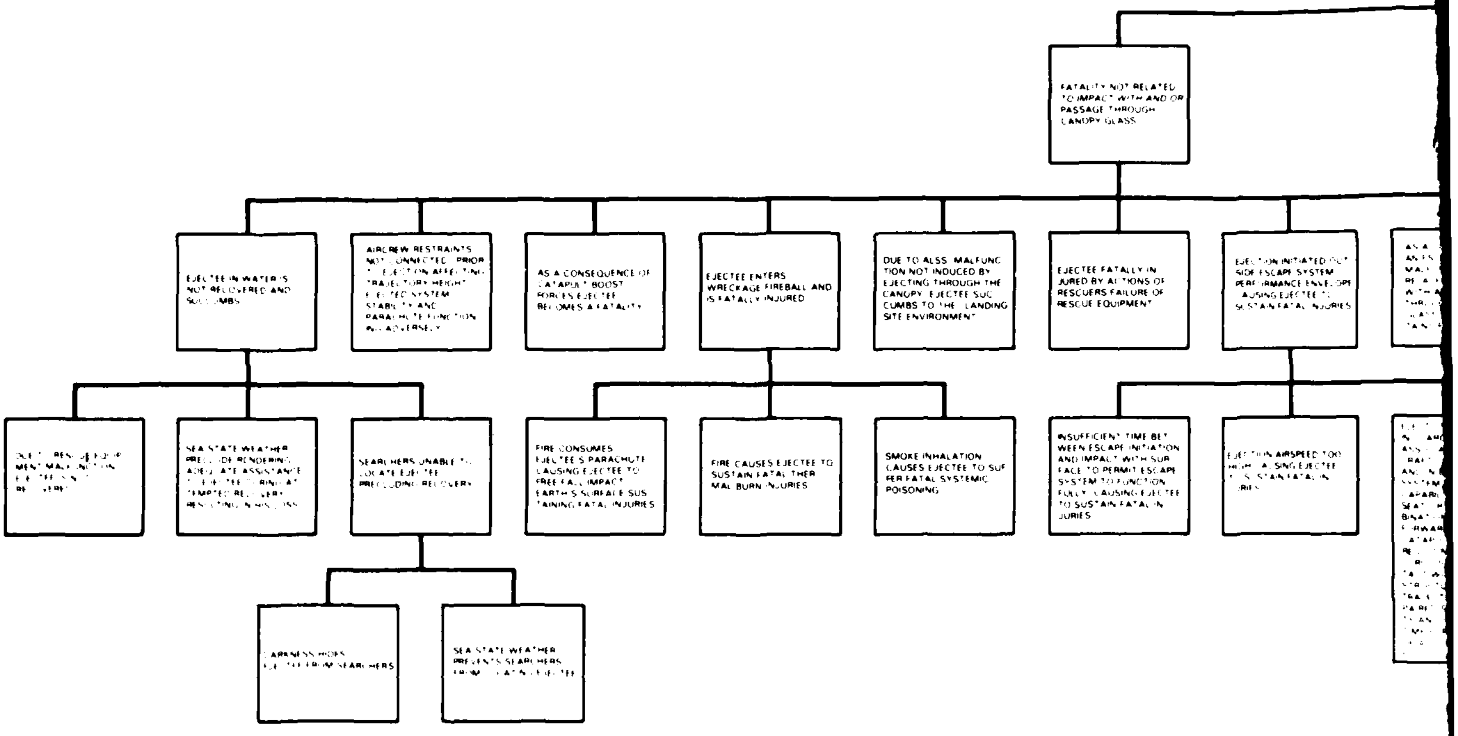
1

CAUSES FOR JETTISONED-CANOPY EJECTION FATALITY



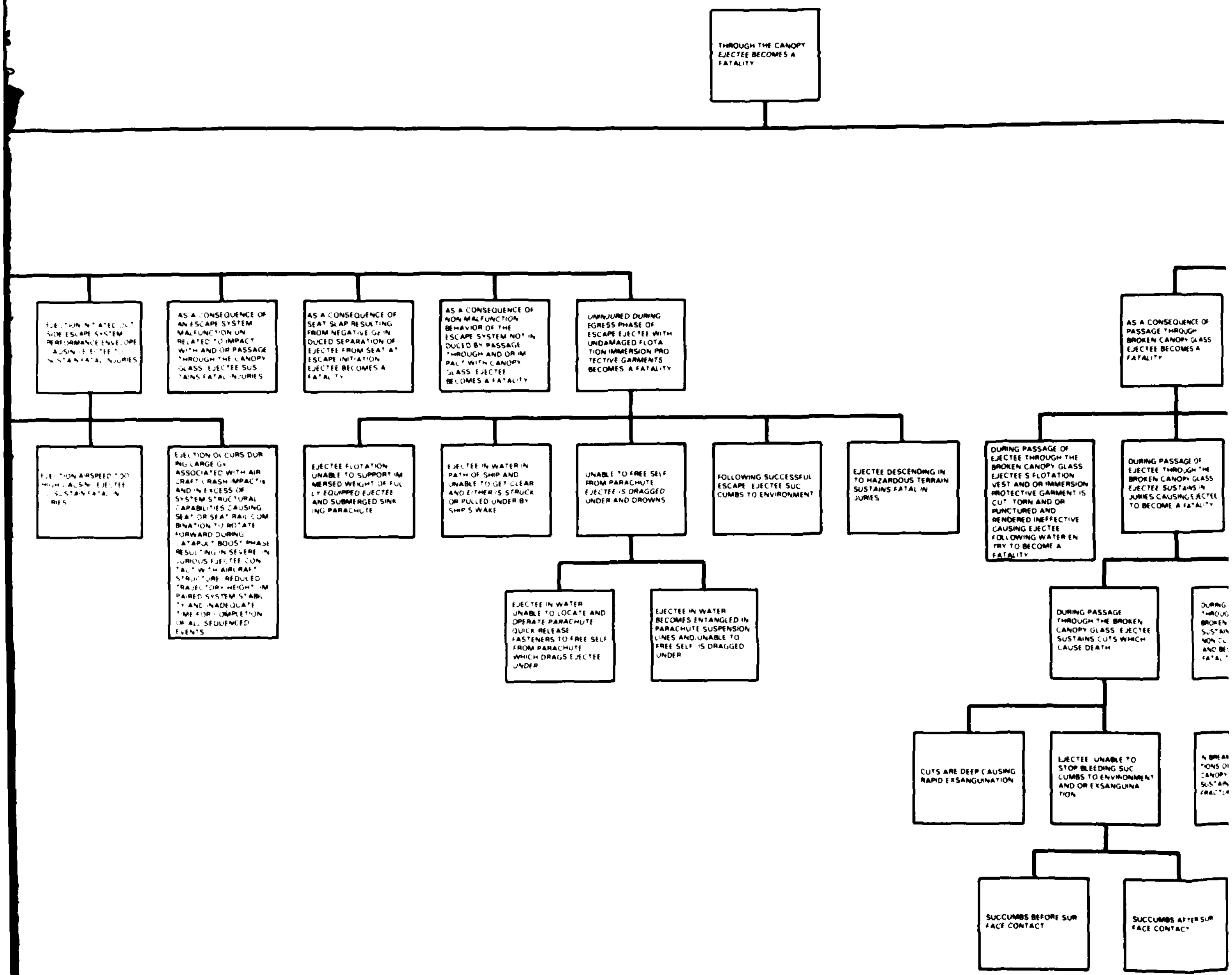
2

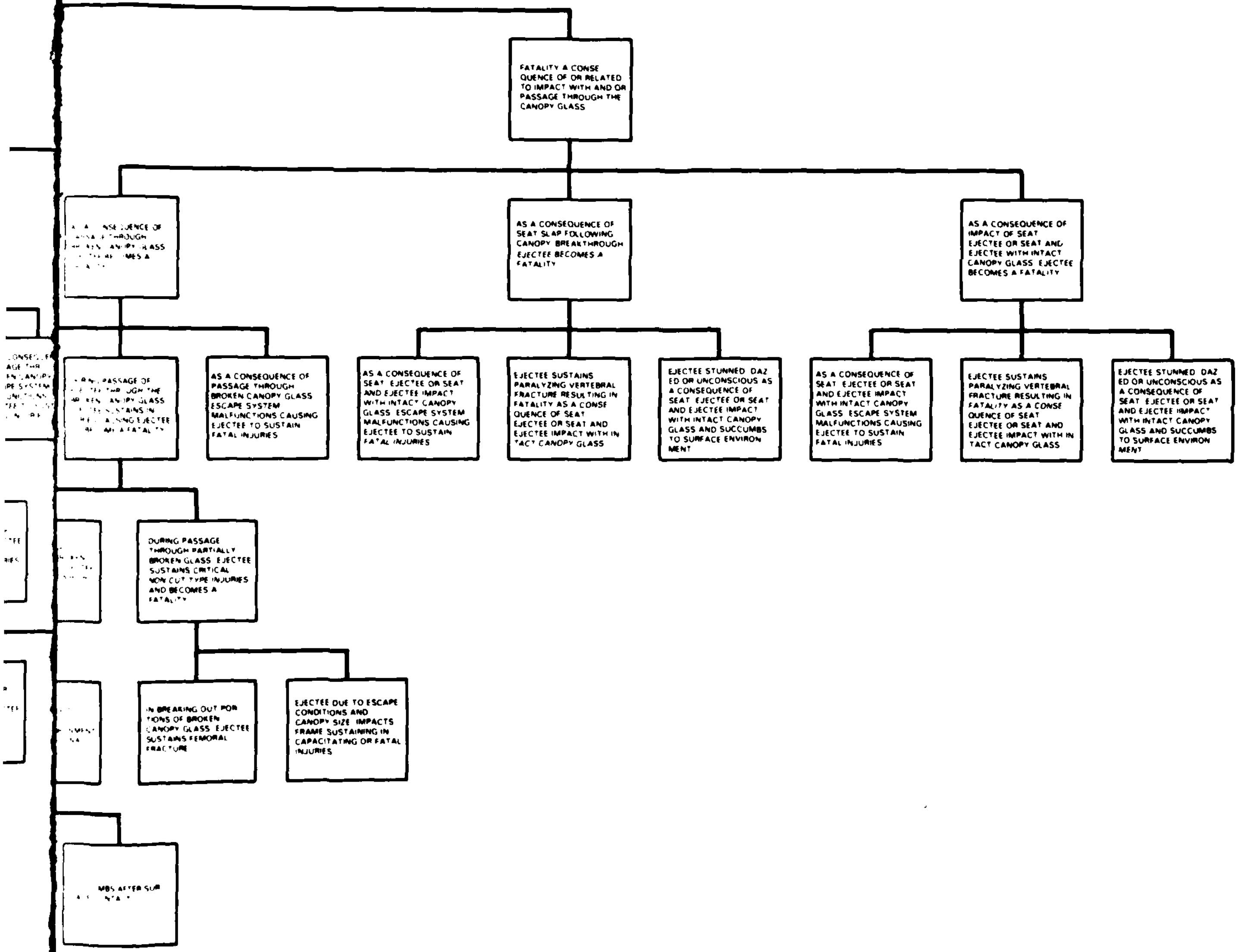

CANOPY FAILS TO JETTISON PRECLUDING EJECTION OF AIRCREW WHO SUBSEQUENTLY PERISH IN CRASH OF AIRCRAFT
CANOPY JETTISONING IS TOO SLOW CAUSING EJECTING SEAT AIRCREW TO COLLIDE WITH IT INFLICTING FATAL INJURIES UPON AIRCREW
FLIGHT FORCES DELAY CANOPY JETTISONING AND THEREFORE SEAT AIRCREW EJECTION SUFFICIENTLY LONG AS TO IMPAIR SYSTEM OPERATION WITH FATAL CONSEQUENCES
JETTISONING AND EJECTION OCCUR DURING LARGE G_x FORCES, CAUSING CANOPY TO CLOSE AFTER OPENING IMPACTING SEAT AND DAMAGING SEAT, INJURING OCCUPANT AND/OR ALTERING TRAJECTORY IN MANNER PRECLUDING EJECTEE SURVIVAL



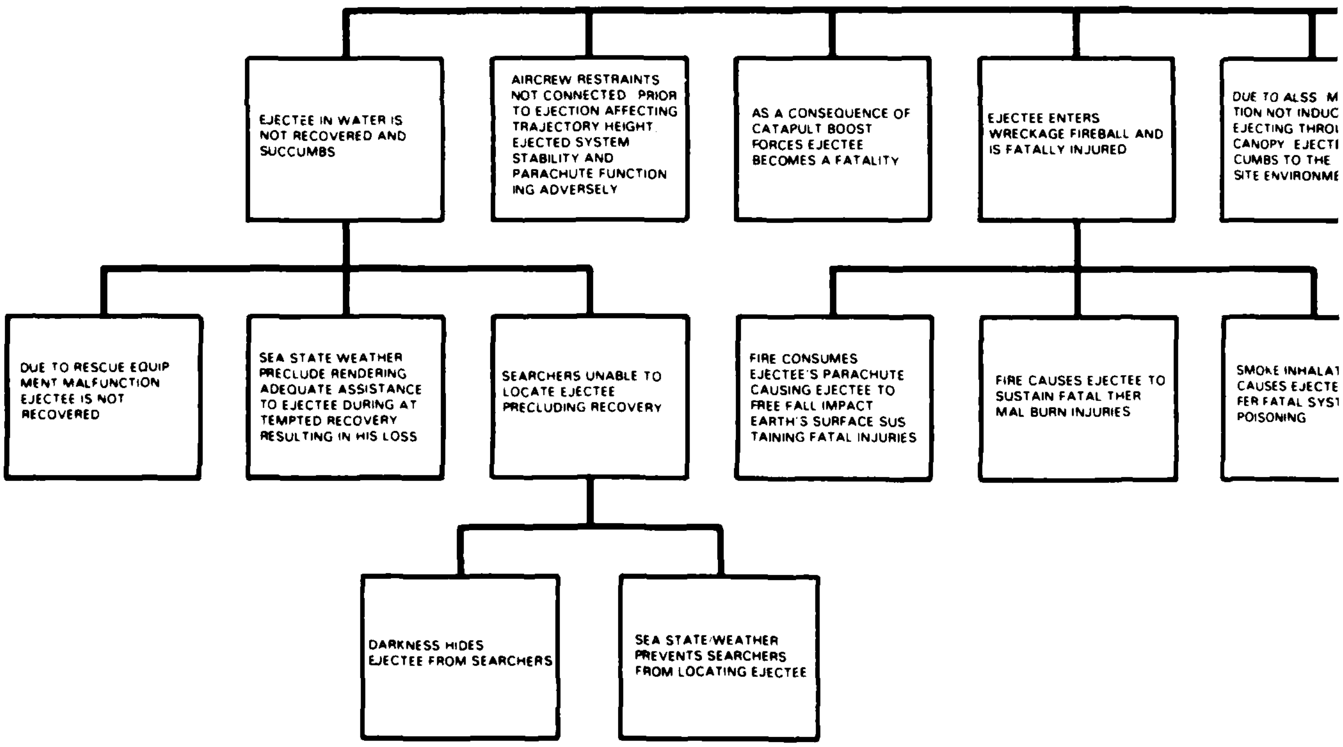
FATALITY NOT RELATED TO IMPACT WITH AND OR PASSAGE THROUGH CANOPY GLASS
AS A CONSEQUENCE OF CATAPULT BOOST FORCES EJECTEE BECOMES A FATALITY
EJECTEE ENTERS WRECKAGE FIREBALL AND IS FATALLY INJURED
DUE TO ALSS MALFUNCTION NOT INDUCED BY EJECTING THROUGH THE CANOPY EJECTEE SUCCUMBS TO THE LANDING SITE ENVIRONMENT
EJECTEE FATALLY INJURED BY ACTIONS OF RESCUERS FAILURE OF RESCUE EQUIPMENT
FIRE CONSUMES EJECTEE'S PARACHUTE CAUSING EJECTEE TO FREE FALL IMPACT EARTH'S SURFACE SUSTAINING FATAL INJURIES
FIRE CAUSES EJECTEE TO SUSTAIN FATAL THERMAL BURN INJURIES
SMOKE INHALATION CAUSES EJECTEE TO SUFFER FATAL SYSTEMIC POISONING
INSUFFICIENT TIME BETWEEN ESCAPE INITIATION AND IMPACT WITH SURFACE TO PERMIT ESCAPE SYSTEM TO FUNCTION FULLY CAUSING EJECTEE TO SUSTAIN FATAL INJURIES

CAUSES FOR THROUGH-THE-CANOPY EJECTION FATALITY

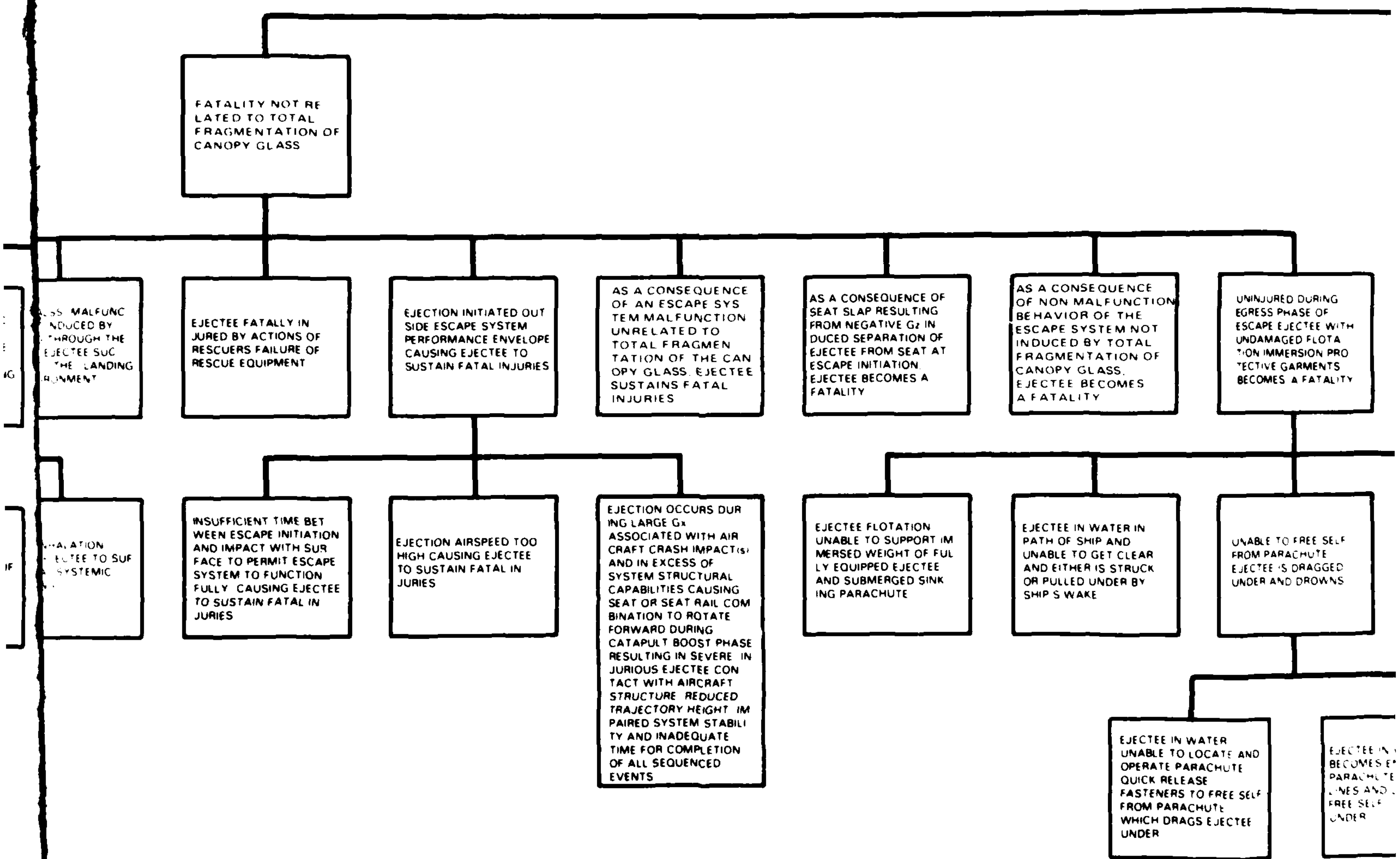


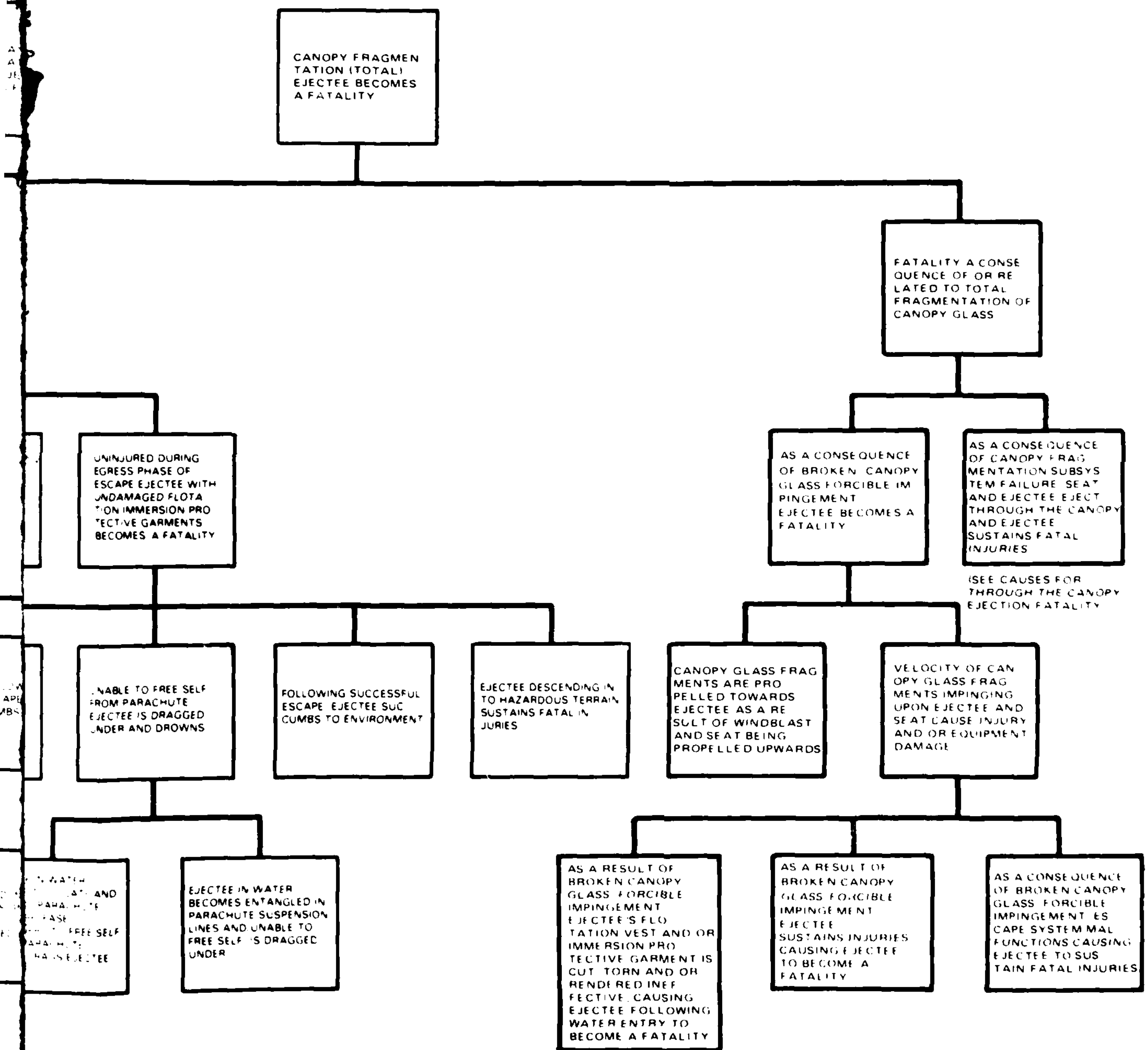

FATALITY A CONSEQUENCE OF OR RELATED TO IMPACT WITH AND OR PASSAGE THROUGH THE CANOPY GLASS
AS A CONSEQUENCE OF SEAT SLAP FOLLOWING CANOPY BREAKTHROUGH EJECTEE BECOMES A FATALITY
AS A CONSEQUENCE OF IMPACT OF SEAT EJECTEE OR SEAT AND EJECTEE WITH INTACT CANOPY GLASS EJECTEE BECOMES A FATALITY
AS A CONSEQUENCE OF PASSAGE THROUGH BROKEN CANOPY GLASS ESCAPE SYSTEM MALFUNCTIONS CAUSING EJECTEE TO SUSTAIN FATAL INJURIES
AS A CONSEQUENCE OF SEAT EJECTEE OR SEAT AND EJECTEE IMPACT WITH INTACT CANOPY GLASS ESCAPE SYSTEM MALFUNCTIONS CAUSING EJECTEE TO SUSTAIN FATAL INJURIES
EJECTEE SUSTAINS PARALYZING VERTEBRAL FRACTURE RESULTING IN FATALITY AS A CONSEQUENCE OF SEAT EJECTEE OR SEAT AND EJECTEE IMPACT WITH INTACT CANOPY GLASS
EJECTEE STUNNED DAZED OR UNCONSCIOUS AS A CONSEQUENCE OF SEAT EJECTEE OR SEAT AND EJECTEE IMPACT WITH INTACT CANOPY GLASS AND SUCCUMBS TO SURFACE ENVIRONMENT
AS A CONSEQUENCE OF SEAT EJECTEE OR SEAT AND EJECTEE IMPACT WITH INTACT CANOPY GLASS ESCAPE SYSTEM MALFUNCTIONS CAUSING EJECTEE TO SUSTAIN FATAL INJURIES
EJECTEE SUSTAINS PARALYZING VERTEBRAL FRACTURE RESULTING IN FATALITY AS A CONSEQUENCE OF SEAT EJECTEE OR SEAT AND EJECTEE IMPACT WITH INTACT CANOPY GLASS
EJECTEE STUNNED DAZED OR UNCONSCIOUS AS A CONSEQUENCE OF SEAT EJECTEE OR SEAT AND EJECTEE IMPACT WITH INTACT CANOPY GLASS AND SUCCUMBS TO SURFACE ENVIRONMENT
DURING PASSAGE THROUGH PARTIALLY BROKEN GLASS EJECTEE SUSTAINS CRITICAL NON CUT TYPE INJURIES AND BECOMES A FATALITY
IN BREAKING OUT PORTIONS OF BROKEN CANOPY GLASS EJECTEE SUSTAINS FEMORAL FRACTURE
EJECTEE DUE TO ESCAPE CONDITIONS AND CANOPY SIZE IMPACTS FRAME SUSTAINING INCAPACITATING OR FATAL INJURIES

3


EJECTEE IN WATER IS NOT RECOVERED AND SUCCUMBS
AIRCREW RESTRAINTS NOT CONNECTED PRIOR TO EJECTION AFFECTING TRAJECTORY HEIGHT, EJECTED SYSTEM STABILITY AND PARACHUTE FUNCTIONING ADVERSELY
AS A CONSEQUENCE OF CATAPULT BOOST FORCES EJECTEE BECOMES A FATALITY
EJECTEE ENTERS WRECKAGE FIREBALL AND IS FATALLY INJURED
DUE TO RESCUE EQUIPMENT MALFUNCTION EJECTEE IS NOT RECOVERED
SEA STATE WEATHER PRECLUDE RENDERING ADEQUATE ASSISTANCE TO EJECTEE DURING ATTEMPTED RECOVERY RESULTING IN HIS LOSS
SEARCHERS UNABLE TO LOCATE EJECTEE PRECLUDING RECOVERY
FIRE CONSUMES EJECTEE'S PARACHUTE CAUSING EJECTEE TO FREE FALL IMPACT EARTH'S SURFACE SUSTAINING FATAL INJURIES
FIRE CAUSES EJECTEE TO SUSTAIN FATAL THERMAL BURN INJURIES
DARKNESS HIDES EJECTEE FROM SEARCHERS
SEA STATE/WEATHER PREVENTS SEARCHERS FROM LOCATING EJECTEE

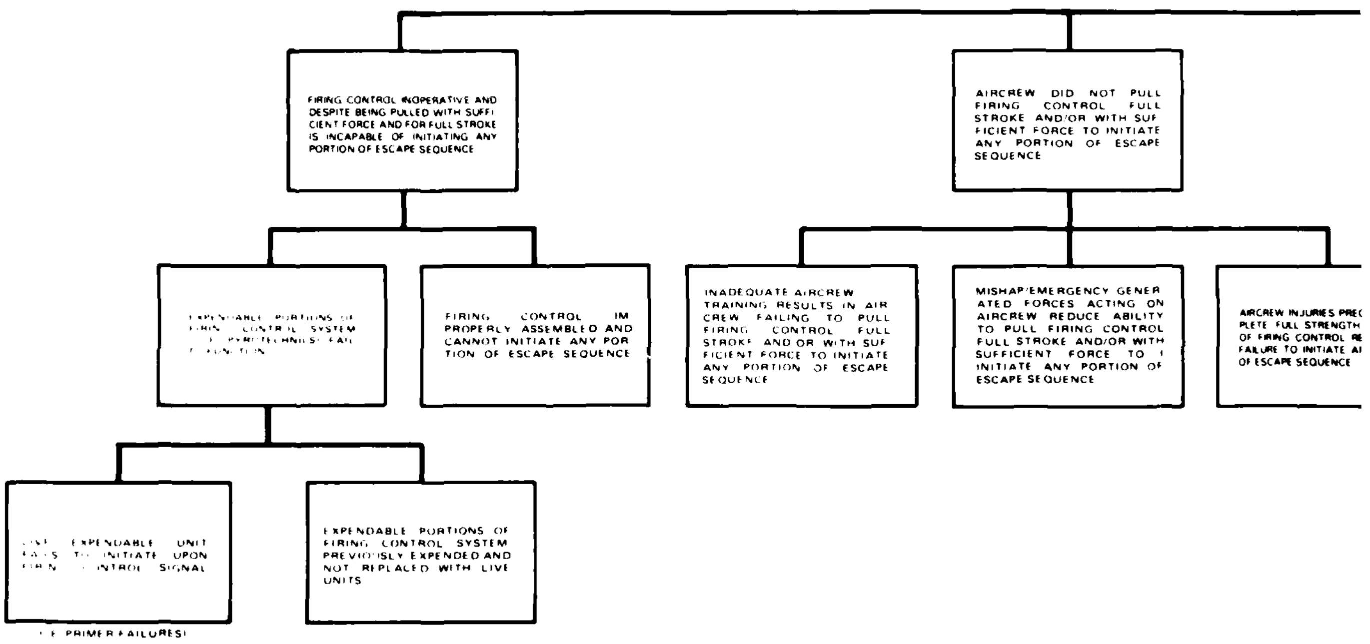
CAUSES FOR CANOPY FRAGMENTATION (TOTAL) FATALITY





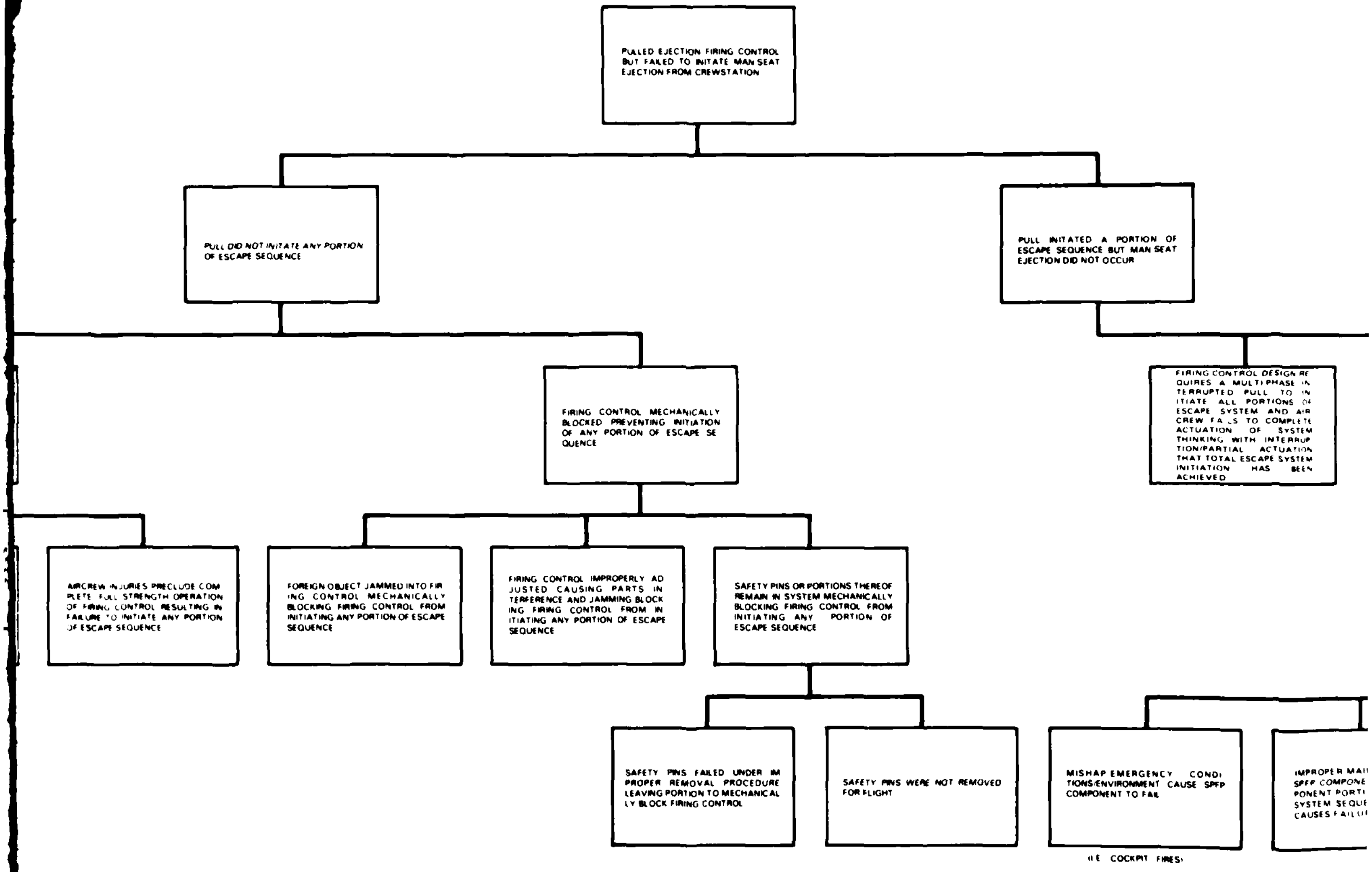
CANOPY FRAGMENTATION (TOTAL) EJECTEE BECOMES A FATALITY
FATALITY A CONSEQUENCE OF OR RELATED TO TOTAL FRAGMENTATION OF CANOPY GLASS
UNINJURED DURING EGRESS PHASE OF ESCAPE EJECTEE WITH UNDAMAGED FLOTATION IMMERSION PROTECTIVE GARMENTS BECOMES A FATALITY
AS A CONSEQUENCE OF BROKEN CANOPY GLASS FORCIBLE IMPINGEMENT EJECTEE BECOMES A FATALITY
AS A CONSEQUENCE OF CANOPY FRAGMENTATION SUBSYSTEM FAILURE SEAT AND EJECTEE EJECT THROUGH THE CANOPY AND EJECTEE SUSTAINS FATAL INJURIES
(SEE CAUSES FOR THROUGH THE CANOPY EJECTION FATALITY
UNABLE TO FREE SELF FROM PARACHUTE EJECTEE IS DRAGGED UNDER AND DROWNS
FOLLOWING SUCCESSFUL ESCAPE EJECTEE SUCCUMBS TO ENVIRONMENT
EJECTEE DESCENDING INTO HAZARDOUS TERRAIN SUSTAINS FATAL INJURIES
CANOPY GLASS FRAGMENTS ARE PROPELLED TOWARDS EJECTEE AS A RESULT OF WINDBLAST AND SEAT BEING PROPELLED UPWARDS
VELOCITY OF CANOPY GLASS FRAGMENTS IMPINGING UPON EJECTEE AND SEAT CAUSE INJURY AND OR EQUIPMENT DAMAGE
EJECTEE IN WATER BECOMES ENTANGLED IN PARACHUTE SUSPENSION LINES AND UNABLE TO FREE SELF IS DRAGGED UNDER
AS A RESULT OF BROKEN CANOPY GLASS FORCIBLE IMPINGEMENT EJECTEE'S FLOTATION VEST AND OR IMMERSION PROTECTIVE GARMENT IS CUT TORN AND OR RENDERED INEFFECTIVE CAUSING EJECTEE FOLLOWING WATER ENTRY TO BECOME A FATALITY
AS A RESULT OF BROKEN CANOPY GLASS FORCIBLE IMPINGEMENT EJECTEE SUSTAINS INJURIES CAUSING EJECTEE TO BECOME A FATALITY
AS A CONSEQUENCE OF BROKEN CANOPY GLASS FORCIBLE IMPINGEMENT ESCAPE SYSTEM MALFUNCTIONS CAUSING EJECTEE TO SUSTAIN FATAL INJURIES

7

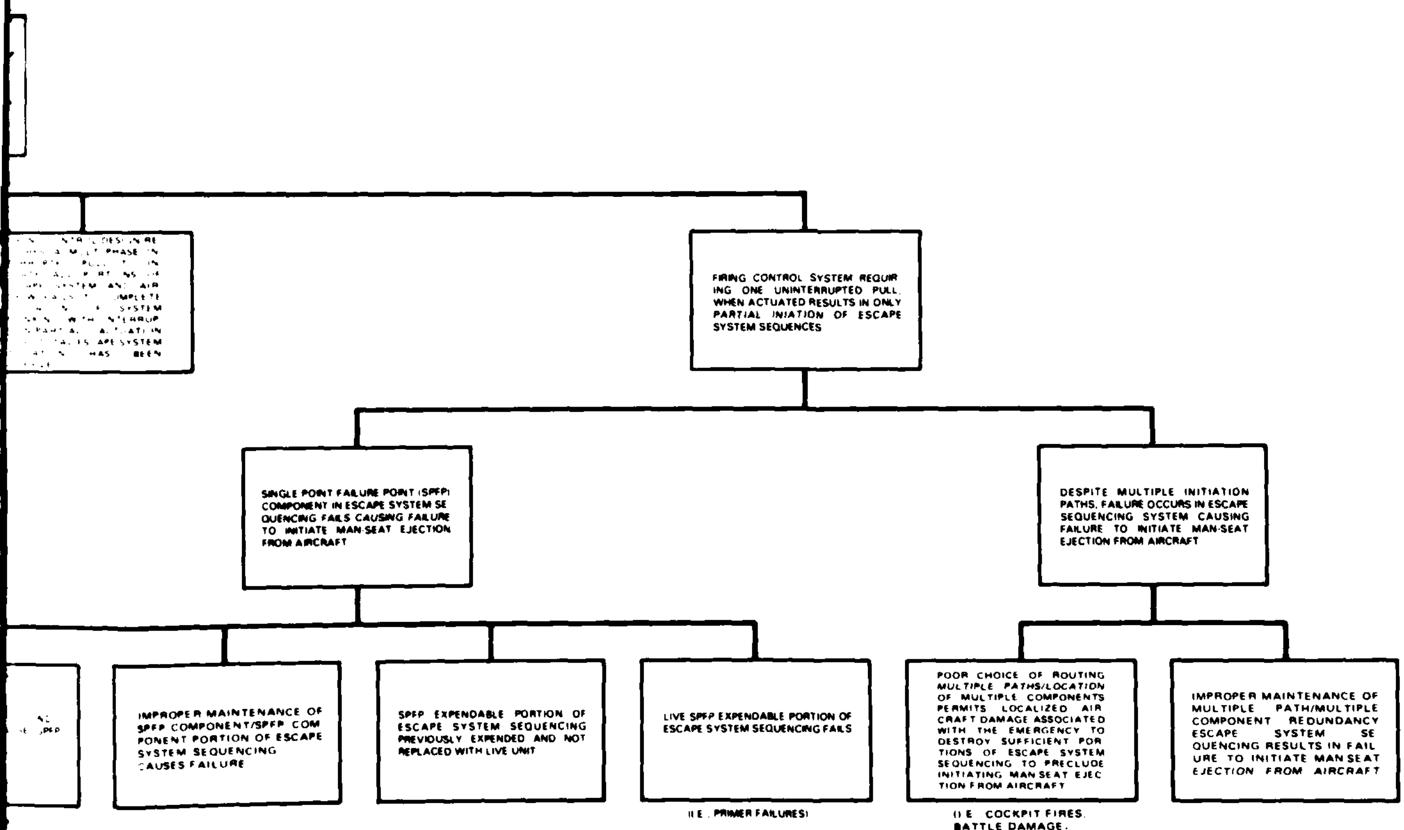

FIRING CONTROL INOPERATIVE AND DESPITE BEING PULLED WITH SUFFICIENT FORCE AND FOR FULL STROKE IS INCAPABLE OF INITIATING ANY PORTION OF ESCAPE SEQUENCE
AIRCREW DID NOT PULL FIRING CONTROL FULL STROKE AND/OR WITH SUFFICIENT FORCE TO INITIATE ANY PORTION OF ESCAPE SEQUENCE
FIRING CONTROL IMPROPERLY ASSEMBLED AND CANNOT INITIATE ANY PORTION OF ESCAPE SEQUENCE
INADEQUATE AIRCREW TRAINING RESULTS IN AIRCREW FAILING TO PULL FIRING CONTROL FULL STROKE AND/OR WITH SUFFICIENT FORCE TO INITIATE ANY PORTION OF ESCAPE SEQUENCE
MISHAP/EMERGENCY GENERATED FORCES ACTING ON AIRCREW REDUCE ABILITY TO PULL FIRING CONTROL FULL STROKE AND/OR WITH SUFFICIENT FORCE TO INITIATE ANY PORTION OF ESCAPE SEQUENCE
AIRCREW INJURIES PREC
PLETE FULL STRENGTH
OF FIRING CONTROL RE
FAILURE TO INITIATE AI
OF ESCAPE SEQUENCE
EXPENDABLE PORTIONS OF FIRING CONTROL SYSTEM PREVIOUSLY EXPENDED AND NOT REPLACED WITH LIVE UNITS
PRIMER FAILURES

1

CAUSES FOR TYPE 3 EJECTION (ATTEMPTED (NOT ACCOMPLISHED)



2


FIRING CONTROL SYSTEM REQUIRING ONE UNINTERRUPTED PULL, WHEN ACTUATED RESULTS IN ONLY PARTIAL INIATION OF ESCAPE SYSTEM SEQUENCES
SINGLE POINT FAILURE POINT (SFFP) COMPONENT IN ESCAPE SYSTEM SEQUENCING FAILS CAUSING FAILURE TO INITIATE MAN-SEAT EJECTION FROM AIRCRAFT
DESPITE MULTIPLE INITIATION PATHS, FAILURE OCCURS IN ESCAPE SEQUENCING SYSTEM CAUSING FAILURE TO INITIATE MAN-SEAT EJECTION FROM AIRCRAFT
IMPROPER MAINTENANCE OF SPFP COMPONENT/SPFP COMPONENT PORTION OF ESCAPE SYSTEM SEQUENCING CAUSES FAILURE
SPFP EXPENDABLE PORTION OF ESCAPE SYSTEM SEQUENCING PREVIOUSLY EXPENDED AND NOT REPLACED WITH LIVE UNIT
LIVE SPFP EXPENDABLE PORTION OF ESCAPE SYSTEM SEQUENCING FAILS
(I.E., PRIMER FAILURES)
POOR CHOICE OF ROUTING MULTIPLE PATHS/LOCATION OF MULTIPLE COMPONENTS PERMITS LOCALIZED AIRCRAFT DAMAGE ASSOCIATED WITH THE EMERGENCY TO DESTROY SUFFICIENT PORTIONS OF ESCAPE SYSTEM SEQUENCING TO PRECLUDE INITIATING MAN SEAT EJECTION FROM AIRCRAFT
(I.E. COCKPIT FIRES, BATTLE DAMAGE.
IMPROPER MAINTENANCE OF MULTIPLE PATH/MULTIPLE COMPONENT REDUNDANCY ESCAPE SYSTEM SEQUENCING RESULTS IN FAILURE TO INITIATE MAN SEAT EJECTION FROM AIRCRAFT

3

AN ANALYSIS OF THE FATALITY RATE DATA FROM "JETTISON-CANOPY" AND "THROUGH-CANOPY" EJECTIONS FROM AUTOMATED AIRBORNE ESCAPE SYSTEMS

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The problem associated with the escape from a disabled aircraft has been the cause for a great deal of concern and effort toward their resolution. One aspect of escape which is of utmost importance to survival is the timeliness of the ejection process. Survival may be determined in a matter of seconds or even milliseconds; thus, changes that decrease the time-to-escape will logically increase survivability. One method for decreasing the time to escape is for the seat to eject through the canopy as opposed to the process of jettisoning the canopy followed by seat ejection. It has been estimated[1] that approximately 300 milliseconds elapse while the canopy is jettisoned and the ejectee's upper torso and extremeties are pre-positioned for ejection. For certain environmental situations such as low altitude, high speed, etc., this 300 milliseconds can be extremely critical. In such situations, through-the-canopy ejections would be preferred to the jettison canopy method with all other things equal. Problems exist, however, with through-the-canopy ejection, especially if the ejectee has not been properly pre-positioned before the ejection takes place.

This paper presents an examination of U.S. Navy data for ejections that occurred during the eleven (11) year period 1969 - 1979. These data represent all ejections attempted including those ejections which were inadvertant or unintentional. These data are examined from a statistical viewpoint and not from an engineering viewpoint. The purpose of the examination is to provide some feedback to the

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1/ Raddin, Specker and Brinkley, "Minimizing the Sequenced Delay Time for Escape From High-Speed, Low-Level Flight Profiles," AGARD Conference Proceedings No. 267

engineers and decision makers on the specific question "Jettison or Through-the-Canopy; which should be used?"

The analyses examine data recorded for variables such as conditions at the time of ejection, the aircraft and ejection seat models, the site or terrain over which the ejection occurred and the injuries sustained during the ejection. The conditions at the time of ejection recorded in the data include the altitude, speed, pitch and bank of the aircraft. Design variables recorded in the data include the seat type, number of seats in the aircraft and the canopy design. The effect of these variables upon the survival rate of ejectees has been investigated wherever possible and comparisons between "Through-the-Canopy" and "Jettison-Canopy" ejections are examined.

The analysis effort has just recently been undertaken and only preliminary results can be presented at this time. The analytical tools employed in the analysis have included multivariate analysis and its discrete counterpart multivariate cross-classification analysis. These techniques allow for the simultaneous examination of several variables at one time and for the measurement of interaction effects among the variables. The emphasis has been on the application of quantitative methods to these data and not on the physical, engineering or medical analyses.

JETTISON AND THROUGH-CANOPY EJECTIONS

There were 1376 ejections (Types 1, 2, 3, 5 and 6 as defined by OPNAVINST) during the period of 1969 - 1979. These ejections have been partitioned in Table 1 by the mode of ejection identified as either "Through-the-Canopy" (TC) or "Jettisoned-Canopy" (JC). The fatality rates are different between the modes of ejection in that the difference

is too great to be due to chance variation. But, is the difference due to the mode of ejection or to some other factor that is hidden by this partitioning? Could this observed difference result from some change that occurred during the eleven year period entirely independent of the mode of ejection? The observed difference in fatality rates could possibly be explained if the TC ejections occurred during a period of calendar time when fatality rates were high and, although some JC ejections occurred during that period, the majority occurred during a period of low fatality rates. If the TC ejections occurred in risk situations during which the JC ejections did not occur, then these observed differences could be due to the risk-situation differences, rather than the mode of ejection. These possible risk-differences suggest that further investigation must be undertaken to more fully understand the data and the way these data were generated if we are to arrive at a proper interpretation and if a sound decision is to be rendered.

Table 1. Fatality Rates for "Through-the-Canopy" (TC) and "Jettison Canopy" (JC) Type of Ejection Seats Based Upon All AAES Ejections of Types 1, 2, 3, 5 and 6 for the Period 1969 - 1979

	Mode of Ejection		Total
	TC	JC	
Fatalities	59	176	235
Total	241	1,135	1,376
Percent	24.5	15.5	17.1

PARTITION EJECTIONS BY CALENDAR TIME

One question that arises immediately when one deals with data that have accrued over a period of time is, "Have there been changes which occurred within the observation period?" If there are differences, say in seat design or the method of reporting, during the period of observation, then these differences might hide other more important differences or be hidden by other unimportant differences.

Table 2 displays the number of ejections by year from 1969 through 1979 and these ejections are partitioned into number of fatalities, number of survivors and percent of survivors for each of the mode of ejections. A further division was made between the period before 1974 and the period after 1973 because of a change in the definition of an ejection attempt. A discussion of this difference is presented in another paper entitled "Problems With the Use of Percentages in the Analysis of Ejection Fatalities," and it is included in the proceedings of this symposium.

The percent of the ejectees that survived ejection are plotted in Figure 1 for each calendar year and mode of ejection. Each of the time periods shows a difference between the modes of ejection and the difference is consistent between time periods. The change in definition affected the survival rates of the modes of ejection equally. The decrease in the number of ejections between the two periods was primarily in the "Jettison" ejection mode rather than in the "Through-Canopy" mode.

Table 2. Ejections and Fatalities by Year for the Jettison Canopy and Through the Canopy Modes of Ejection

Year	Jettison				Through				Total Combined
	Fatal	Surv.	Total	%	Fatal	Surv.	Total	%	%
1969	27	191	218	87.6	10	25	35	71.4	85.3
1970	31	144	175	82.3	7	21	28	75.0	81.3
1971	19	106	125	84.8	1	23	24	95.8	86.6
1972	16	120	136	88.2	7	19	26	73.1	85.8
1973	16	100	116	86.2	4	10	14	71.4	84.6
Subtotal	109	661	770	85.8	29	98	127	77.2	84.6
1974	11	54	65	83.1	4	6	10	60.0	80.0
1975	14	54	68	79.4	4	22	26	84.6	80.9
1976	15	49	64	76.6	6	15	21	71.4	75.3
1977	13	60	73	82.2	5	14	19	73.7	80.4
1978	9	42	51	82.4	7	19	26	73.1	79.2
1979	4	39	43	90.7	5	7	12	58.3	83.6
Subtotal	66	298	364	81.9	31	83	114	72.8	79.7
Total	175	959	1,134	84.6	60	181	241	75.1	82.9

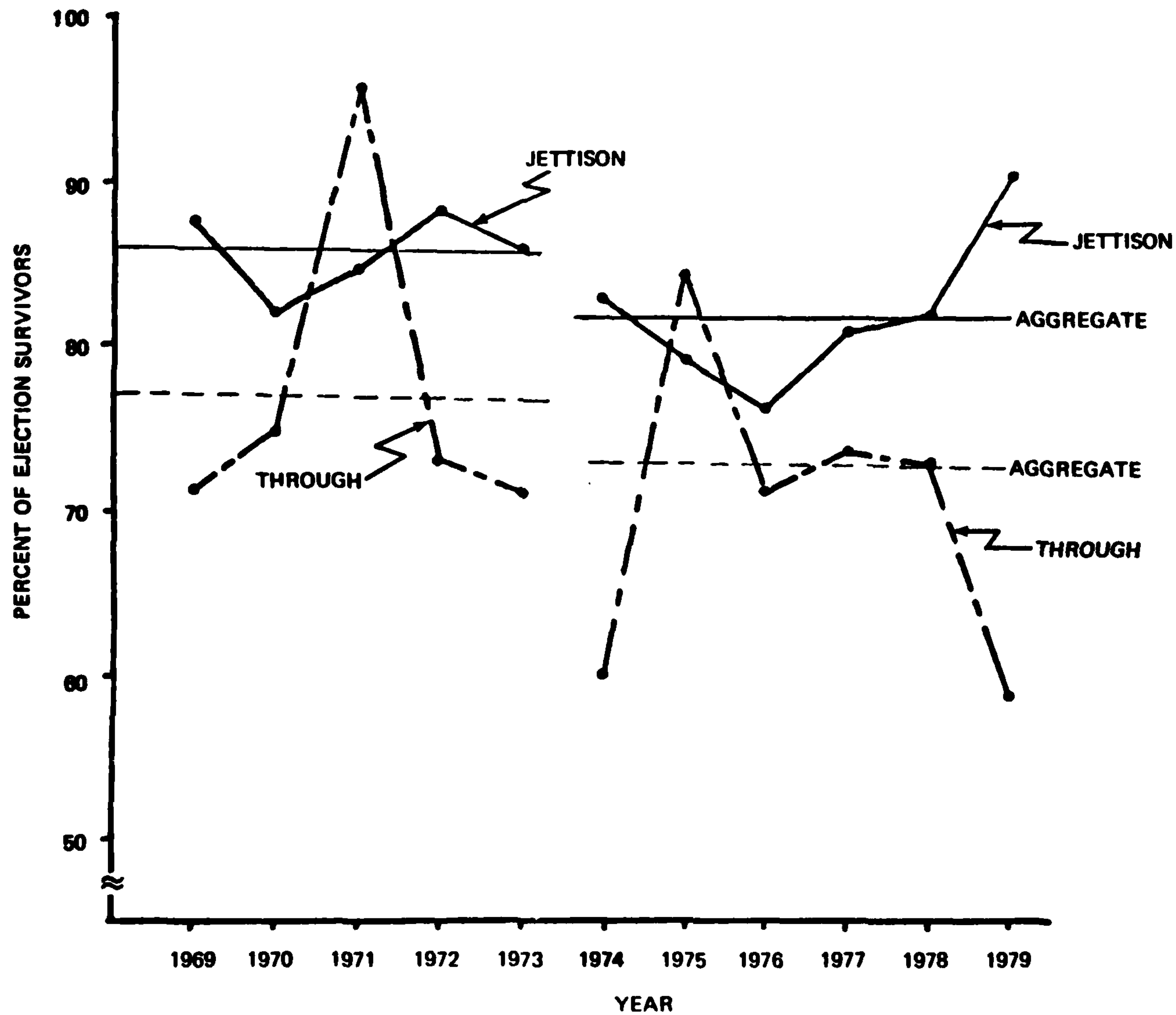


Figure 1. The Yearly Survival Percentage for the AAES During the 1969-73 and 1974-79 Periods Partitioned by "Through-Canopy" and "Jettison-Canopy" With the Aggregate Percentage for the Periods Superimposed

INFLUENCING FACTORS ON FATALITY RATES

There are several factors that can affect the fatality rates of ejections. Among these factors are hardware design and the "situational conditions" at the time the systems are used. We shall refer to these different factors as design factors (characteristics) and risk (environmental situations) factors.

The design factors, as used herein, are those characteristics that are inherent in the hardware design and/or the interface with other hardware systems. Examples of design factors are aircraft-seat interface characteristics, mode of ejection, method of separation of seat and occupant, method of the reduction of the descent rate of occupant after seat-occupant separation, method of protecting the occupant(s) from the aerodynamic forces, etc.

The risk factors, as used herein, are those factors that are external to the AAES and reflect perceived danger associated with the aircraft conditions at the time of the escape of the occupant. Differences in risk must be recognized in evaluating any difference in fatality rates and, therefore, these risk differences can determine the method of data analysis to employ. Examples of risk factors are the speed, altitude, attitude, and rate-of-descent of the aircraft at the time of ejection, the location and terrain under the aircraft at ejection, etc.

Is there a difference in fatality rates among different risk situations? If fatality rates are different between two risk situations, then is it possible that the risk levels are different between the two modes of ejection? A partition of the ejection events that occurred during the 1969 - 1979 period by risk categories defined in terms of speed and altitude at time of ejection is presented as Table 3. It is clear that the risk associated with the various combinations of speed and altitude are different based upon the fatality rates observed during the period (aggregated over aircraft types, seat types, mode of ejection, etc.).

The fatality rates experienced during this observation period reflect a dependence upon both speed and altitude at the time of ejection. This result is not unexpected, but it does demonstrate that differences in speed and altitude at the time of ejection are important in the analysis of fatality rates. This experience data indicates that for any fixed (given) speed, the fatality rate will depend upon the altitude at ejection - the lower the altitude the higher the rate. Conversely, the data indicates that for any fixed (given) altitude, the fatality rate will depend upon the speed at the time of ejection - the higher the speed the greater the rate. These observed differences in fatality rates associated with differences in risk category or level suggests that any comparisons between modes of ejection should be made within the same risk category.

Recognizing that the risk category may result in different fatality rates, it becomes necessary to compare the mode of ejections (TC vs JC) within risk cells where both modes are subjected to the same or similar risk conditions.

Table 3. Fatality Rates for Various Categories of Speed and Altitude at the Time of Ejection for AAES (Types 1, 2, 3, 5, 6 Ejections) From 1969 - 1979 Experience Data

Altitude	F= fatalities T= total ejections %= F/T	Speed			Total
		Low (<200)	Med. (200-500)	High (>500)	
Low (<200')	F T	110 452	18 26	14 16	142 494
	%	24.3	69.2	87.5	28.7
Medium (200-5,000)	F T	25 299	29 228	11 16	65 543
	%	8.4	12.7	68.8	12.0
High (>5,000')	F T	3 112	16 209	9 18	28 339
	%	2.7	7.7	50.0	8.3
Total	F T	138 863	63 463	34 50	235 1,376
	%	16.0	13.6	68.0	17.1

What has been determined here is the need to consider the risk levels in attempting to evaluate the effectiveness of different design features. If one had the freedom, a statistical experimental design would be employed to control the effects of these external factors (variables). Unfortunately, one cannot control when and where escape systems will be employed in service use. So, what cannot be controlled in the operational situation must be handled in the analysis.

The ultimate objective of an analysis such as this is to be able to compare the effectiveness of different design features and, through that knowledge, improve future designs. The need to partition the data into multiple risk levels and categories to evaluate design characteristics may appear to be selfdefeating. Such partitioning will result ; complex classification tables that can be very confusing and each cell will have a small number of ejections. Fortunately, there are statistical procedures that can overcome the problem of confusing complex tabular analysis and also to extract the maximum information contained in the data.

COMPARISON OF TC VS JC WITHIN RISK CATEGORIES

Having recognized that the risk category may result in different fatality rates, it becomes necessary to compare the mode of ejections (TC vs JC) within risk cells where both modes are subjected to the same or similar risk conditions. The partitioning of the data in each cell into mode of ejection was performed and these data are presented in Table 4. A look at this table will reveal that the only place where the fatality rates between modes of ejection differ significantly is in one cell! The cell exhibiting the differences in fatality rates between TC

Table 4. Fatality Rates for "Through-the-Canopy" (TC) and "Jettison Canopy" (JC) Type of Ejection Seats for Various Categories of Speed and Altitude for AAES (Types 1, 2, 3, 5, and 6 Ejections) From 1969 - 1979 Experience Data

Altitude		Speed						Total		Total
		Low (<200 KTS)		Med. (200-500)		High (>500 KTS)				
		TC	JC	TC	JC	TC	JC	TC	JC	
Low (<200')	F	36	74	5	13	3	11	44	98	142
	T	87	365	8	18	3	13	98	396	494
	%	41.4	20.3	62.5	72.2	100.0	84.6	45.4	24.7	28.7
Medium (200-5,000)	F	5	20	4	25	2	9	11	54	65
	T	58	241	41	187	3	13	102	441	543
	%	8.6	8.2	9.8	13.4	66.7	69.2	10.8	12.2	12.0
High (>5,000')	F	0	3	3	13	1	8	4	24	28
	T	9	103	28	181	4	14	41	298	339
	%	0	2.9	10.7	7.2	25.0	57.1	9.7	8.1	8.3
Total	F	41	97	12	51	6	28	59	176	235
	T	154	709	77	386	10	40	241	1,135	1,376
	%	26.6	13.7	15.6	13.2	60.0	70.0	24.5	15.5	17.1

and JC is the cell corresponding to the risks of "Low Speed - Low Altitude" at time of ejection, i.e., under 200' in altitude and under 200 kts in speed. In all other risk categories the fatality rates of the two modes of ejection do not differ significantly.

If the "Low Speed - Low Altitude" (LS - LA) risk cell is the only place where the fatality rates for the modes of ejection differ, then it should be enlightening to further explore the data in that cell to determine if there are some other risks that could explain this difference. If time of ejection is critical, then single ejections should exhibit a lower fatality rate than multiple ejections, all other things being equal. Furthermore, if the initial penetration of the canopy is critical, then single-seat ejections and single ejections from multiple-seat aircraft would exhibit similar rates. To explore these possibilities the data in the critical "low speed/low altitude" cell was partitioned by number of seats and ejections. Table 5 shows the data in the "LS - LA" risk cell partitioned for each mode of ejection into subcells identified by single seat, single ejection from multiple-seat aircraft, and multiple ejections. In this expanded table there is no significant difference in fatality rates between modes of ejection for the single seat aircraft ejections; there is a significant difference in fatality rates for single ejections between single and multiple-seat aircraft; and there is a significant difference in fatality rates between modes of ejection for both of the single and multiple ejections in the multiple-seat aircraft. In each case where a significant difference occurs, the TC mode has a greater fatality rate than JC mode.

Table 5. Fatality Rates for TC and JC at Low Altitude (<200') and Low Speed (<200# kts) for Types 1, 2, 3, 5 and 6 During the 1969 - 1979 Period

NUMBER OF SEATS AND NUMBER OF EJECTIONS			MODE OF EJECTION		TOTAL
			TC	JC	
SINGLE SEAT AIRCRAFT	SINGLE EJECTION	F	4	22	26
		T	19	131	150
		%	21.1	16.8	17.3
MULTIPLE SEAT AIRCRAFT	SINGLE EJECTION	F	9	20	29
		T	17	56	73
		%	52.9	34.5	38.9
	MULTIPLE EJECTION	F	23	32	55
		T	51	178	229
		%	45.1	18.4	24.3
TOTAL		F	36	74	110
		T	87	365	452
		%	41.4	20.3	24.3

Further partitioning of the data within this "LS/LA" risk cell is shown in Tables 6 and 7. Table 6 partitions the data within mode of ejection by site over which the ejection occurred. The data does not indicate any difference in fatality rates between the land and water sites. Table 7 partitions the data within mode of ejection by the attitude of the aircraft nose at time of ejection. The lowest fatality rates occur, as expected, when the nose is level at ejection time regardless of the mode of ejection. However, a difference in fatality rates between modes of ejection for multiple seat aircraft is present when the nose is level and when the nose is not level.

Table 6. Fatality Rates for "Through-the-Canopy" (TC) and "Jettison-Canopy" (JC) Type Ejection Seats for Those Ejections at Low Altitude (<200') and Low Speed (<200 kts) Partitioned by the Number of Aircraft Seats, Number of Ejections From the Aircraft and the Site When the Ejections Occurred

NUMBER OF SEATS AND EJECTIONS		MODE OF EJECTION				TOTAL
		TC		JC		
		OVER WATER	OVER LAND	OVER WATER	OVER LAND	
SINGLE SEAT/SINGLE EJECTION	F	4	0	9	13	26
	T	12	7	65	66	150
	%	33.3	0.0	13.8	19.7	17.3
MULTIPLE SEATS/ SINGLE EJECTION	F	1	8	4	16	29
	T	6	11	10	46	73
	%	16.7	72.7	40.0	34.8	39.7
MULTIPLE SEATS/ MULTIPLE EJECTIONS	F	9	14	17	15	55
	T	22	29	75	103	229
	%	40.9	48.3	22.7	14.6	24.0
TOTAL	F	21	15	30	44	110
	T	47	40	150	215	452
	%	44.7	37.5	20.0	20.5	24.3

Table 7. Fatality Rates for "Through-the-Canopy" (TC) and "Jettison Canopy" (JC) Type Ejection Seats for Those Ejections at Low Altitude (< 200') and Low Speed (<200 kts) Partitioned by the Number of Aircraft Seat, Number of Ejections From the Aircraft and Nose Altitude at Ejection

NUMBER OF SEATS AND EJECTIONS		MODE OF EJECTION						TOTAL
		TC			JC			
		PITCH			PITCH			
		NOSE LEVEL	NOT LEVEL	UNK.	NOSE LEVEL	NOT LEVEL	UNK.	
SINGLE SEAT/ SINGLE EJECTION	F	0	1	3	4	9	9	26
	T	4	6	9	44	47	40	150
	%	0.0	16.7	33.3	9.1	19.1	22.5	17.3
MULTIPLE SEATS/ SINGLE EJECTION	F	1	4	4	2	3	15	29
	T	1	6	10	17	12	27	73
	%	100.0	66.7	40.0	11.8	25.0	55.6	39.7
MULTIPLE SEATS/ MULTIPLE EJECTIONS	F	5	11	7	4	16	12	55
	T	13	22	16	50	64	64	229
	%	38.5	50.0	43.8	8.0	25.0	18.8	24.0
TOTAL	F	6	16	14	10	28	36	110
	T	18	34	35	111	123	131	452
	%	33.3	47.1	40.0	9.0	22.8	27.5	24.3
TOTAL	F	6	30		10	64		110
	T	18	69		111	254		452
	%	33.3	43.5		90	25.2		24.3

Table 8 presents the data in summary form where the one risk cell is partitioned from all the other data. The risk cell to which most, if not all, of the differences in fatality rates between modes of ejection can be attributed is the multiple seat aircraft at low speed and low altitude at time of ejection. From this analysis it would be very difficult to conclude that there is a real difference in fatality rates that can be attributed only to the mode of ejection.

Table 8. The Fatality Rates Partitioned by Two Modes of Ejection (TC or JC) and by Two Risk Categories (Low Altitude, Low Speed for Multiple Seat Aircraft or All Others) Based Upon All Ejections (Types 1, 2, 3, 5, and 6) During the Period 1969 - 1979

Risk Category		Mode of Ejection		Total
		TC	JC	
Multiple Seat Aircraft	F	32	52	84
Low Speed and Low Altitude at Ejection	T	68	234	302
	%	47.1	22.2	27.8
All Other Risk Categories	F	27	124	151
	T	173	901	1,074
	%	15.6	13.8	14.1
Total	F	59	176	235
	T	241	1,135	1,376
	%	24.5	15.5	17.1

SUMMARY, FINDINGS AND FUTURE EFFORT

Data on ejection seat effectiveness result whenever an operational situation arises that requires the seat's use. The resulting experience data is therefore not balanced with respect to exposure or trials between types of seats, among manufacturers, between land-water sites or other operational conditions that might be helpful in evaluating relative effectiveness. The data does not result from a planned experiment, but arises from "random" incidents and this phenomenon means that the analysis and interpretation of the resulting data must be done with careful consideration of these imbalances and their implications.

Findings

- TC vs JC (pooled over all aircraft, risk conditions) exhibit different fatality rates.
- The fatality rates for TC and JC (pooled over all conditions) exhibit similar differences between the pre-1974 and post 1973 periods reflecting the change in definitions.
- Altitude and speed risk factors at the time of ejection markedly affect the resulting fatality rates (pooled over all other factors).
- The differences in fatality rates between modes of ejection is dominated by the difference observed in the low altitude - low speed risk situation for the multiple seat aircraft.
- The site (land or water) when ejection occurs does not appear to have any effect on the fatality rates.
- The fatality rates are lower for those ejections that occur when the nose is level and this is true for both modes of ejection.

Future Effort

There are many unanswered questions at this stage of the investigation. The future effort will be directed toward answering some of those questions that appear critical such as:

- Does the fatality rate vary with changes in speed and altitude in the LA - LS risk cell the same as that exhibited over all cells?
- Does altitude or speed dominate in the critical risk cell (LA - LS)?
- Is pilot control or lack thereof as measured by bank and pitch a determinant in the explanation of the observed differences in TC and JC fatality rates?
- Could the excluded ejection codes (0, 4, 7, 8 and unk.) account for the observed difference in TC and JC fatality rates?
- Does sequencing of ejections have an effect on the observed differences in TC and JC fatality rates?
- Are single ejections from multiple-seat aircraft the result of incomplete team ejections?

PRELIMINARY GENERALIZED THOUGHTS CONCERNING EJECTION FLAIL PHENOMENA

FREDERICK C. GUILL

From the earliest recorded usage of ejection seats until the present day, a very major concern among those responsible for, or potentially users of, ejection seats has been, and is, limb flail. The term "limb flail" seems often to evoke strong images of severe, incapacitating injuries whether or not the term "injury" is used in conjunction with it. Under its assigned task to investigate aircrew automated escape systems (AAES) in-service usage problems, the Naval Weapons Engineering Support Activity, Washington, D.C., has begun to review data extracted from MORs (Medical Officer's Reports) in an attempt to ascertain how serious the problem is, i.e., how frequently it occurs and what the consequences of limb flail in fact have been. In addition, the investigation will examine how well the various limb restraints in use within the U.S. Navy function in preventing limb flail and injury which might result from limb flailing.

A common perception concerning limb flailing and limb flail induced injuries associated with ejection is that flail and flail injuries are caused by q force (windblast) and therefore are high-speed ejection phenomena. The common disagreement has not been so much concerning the cause of this phenomena but, rather, as to where the cut-off is between low-speed (and therefore virtually free of the risk of flail) and high-speed ejection. To best understand the flail phenomena it is necessary to redefine it as limb dislodgement followed by limb movement; severe movement, either involving limb collision with structure or objects or involving extreme limb motion, beyond natural limits for the particular limb, results in injury. Thus the flail and flail injury problem involve first the mechanisms for dislodging the limbs and second the mechanisms for moving the limbs once dislodged.

Were q force (windblast) the sole causal agent for ejection associated limb flailing and flailing injuries, then the incidence of flailing should in some manner be directly related to q, that is

$$I_f \alpha\ q$$

where I_f is the incidence rate of flailing among ejectees
q is windblast.

Thus, since

$$q = \frac{1}{2} \alpha\ \rho V^2$$

where ρ is the air density
V is the velocity of the ejectee

the incidence rate should be

$$I_f \quad \alpha\ \rho V^2$$

and since ρ varies over a relatively small range for the majority of U.S. Navy ejections, the flail incidence rate essentially should be directly proportional to the square of the ejection velocity.

U.S. Navy ejection data for the period of 1 January 1969 through 31 December 1979 does not, however, show an incidence rate of flail (i.e., reported incidence of uncontrolled involuntary movement of limbs) that is directly proportional to the square of ejection velocity. Rather, that data indicates the incidence rate increases with increased ejection velocity at a rate significantly less than the square of the ejection velocity. Reported ejection velocity, however, might not in fact reflect the true total speed at ejection (sink rate, spin condition, etc., may result in higher aircraft velocities at ejection than indicated by airspeed indicators). Several aspects of that data suggest mechanisms in addition to windblast. These aspects include:

- o for some seats, a relatively high rates of flail at extremely low ejection airspeeds not involving aircraft manuevers likely to result in significantly higher velocities than indicated by instruments, a lower rate at moderate speeds and a growing rate for higher speeds.

- o occasional descriptions from ejectees in stabilized ejection seats, i.e., ejectees stabilized face into the wind, observing their upper limbs flailing in front of them, ejectees observing their upper limbs flailing and then pulling them back to the protection of their body.

Consider the first step in causing limb flail: the dislodgement of the limb. Limb dislodgement requires either that the limb be unconstrained throughout the ejection sequence or that sufficient force be applied to the limb as to cause it to become unconstrained. There are a number of forces acting upon a man-seat system during an escape sequence which might result in limb dislodgement. The impact of these forces, in turn, is influenced by a number of factors. Chart I is a preliminary description of the causes flail-type limb problems.

For the problem of arm flail the factors affecting arm dislodgement would include:

- o Whether escape was self-initiated or sequence-initiated.

- o If sequence-initiated, the amount of warning received and the the preparatory steps taken.

- o If self-initiated:
  - Whether both hands used to pull firing control.
  - Whether one hand used to pull firing control:
    - Whether second hand grasping firmly the wrist of the hand pulling the firing control.
    - Whether second hand is free.
    - Whether second hand grasping seat or personal equipments for restraint.
    - Whether second hand grasping aircraft engine throttle(s) or control stick.
  - Whether grip is voluntarily relaxed after firing control actuation.
  - Whether handle design impairs grasping strength:
    - Handle cross section too large for effective, strong grasp.
    - Handle cross section too small, causing painful pressure and hence release when forces applied to arms.
    - Handle opening shape and width cause sideward compression of grasping hand when forces applied to arm, thereby weakening grasp.
    - Hand/handle becomes slick inducing hand slippage.
    - Handle location induces incomplete or interfered, and thereby weakened, grasping of the handle.
  - Affect of handle pull stroke and ejectee anthropometry, especially seated shoulder height and functional arm reach.
  - Affect of personnel survival equipment bulk on handle pull and arm protection.
  - Linear accelerations imposed upon the arms as a consequence of:
    - catapult boost
    - sustainer of stabilization devices
      - drogues
      - DART
      - STAPAC
    - personnel parachute deployment and opening

Angular accelerations imposed upon the arms as a consequence of:
  seat tip-off
  instability of seat-man combination
  operation of stabilization devices
    - drogues
    - DART
    - STAPAC
  personnel parachute deployment and opening
Amount of seat yaw exposing arms to windblast vectors forcing arms away from ejectee body

as well as others. The factors influencing the movement of the arm subsequent to its dislodgement would include:

- o Windblast
- o Fully accoutered arm drag area
- o Linear accelerations
- o Angular accelerations
- o Muscular reactions/strength of ejectee

Thus it might be reasonable to expect differences in incidence rates between seat types, dependent upon how the hands were employed, dependent upon free flight behavior of man and seat (i.e., tumbling, spinning, rolling, high linear accelerations, and/or high angular accelerations), and dependent upon type, direction and magnitude of the various force inputs such as catapult boost, rocket firing, drogue opening shock, man-seat separation, and parachute opening shock.

Factors affecting leg dislodgement and subsequent movement would include:

- o Angle of thighs and lower legs to windstream
- o Linear and angular accelerations imposed upon the legs
- o Type of cradeling and constraint imposed upon the legs by the ejectee seat.
  - active leg restraints - where in contact with legs and with seat
  - height of seat sides
  - buttock - poplitical length vs length of thigh support provided by seat pan

Concerning the seriouness of limb flail a preliminary review of the data for survivors suggests that flailing occurred in approximately 10 per cent of the ejections with injury of varying severity in approximately one half of those instances. The incidence of reported limb flail among fatal ejectees has, as yet, not been reviewed but is expected to be exceedingly difficult to determine in view of the frequency with which multiple extreme surface impact injuries occur and also the frequency of the lost category. Examination of limb flail injury severity will also be undertaken.

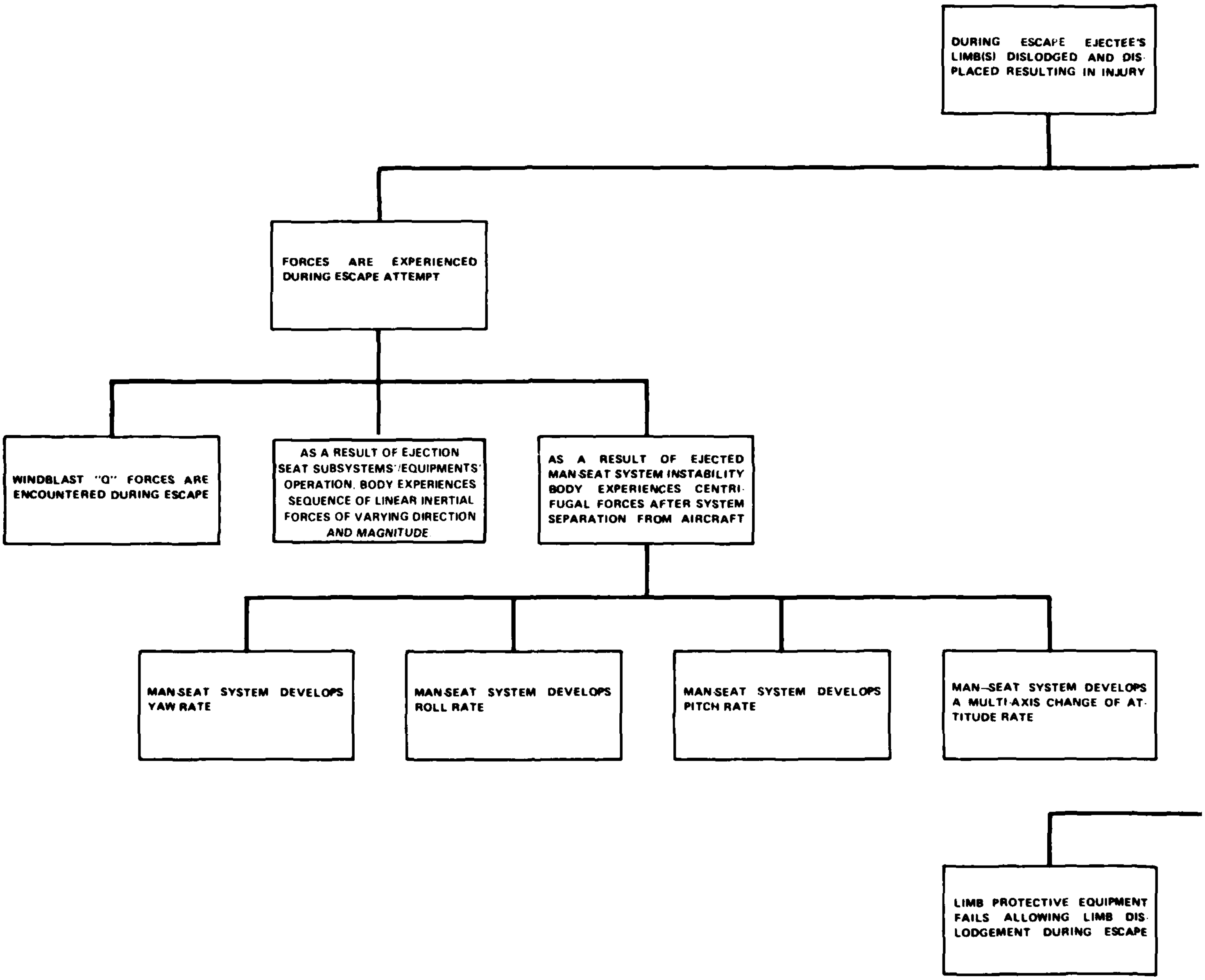
From the narrative data and the incidence rates for limb flail and for limb flail injury it is apparent that limb injury occurrence and severity once a limb has become dislodged is a function of:

- Whether the limb movement is in a direction and sufficiently rapid and extreme to result in injurious contact with the escape system, and/or

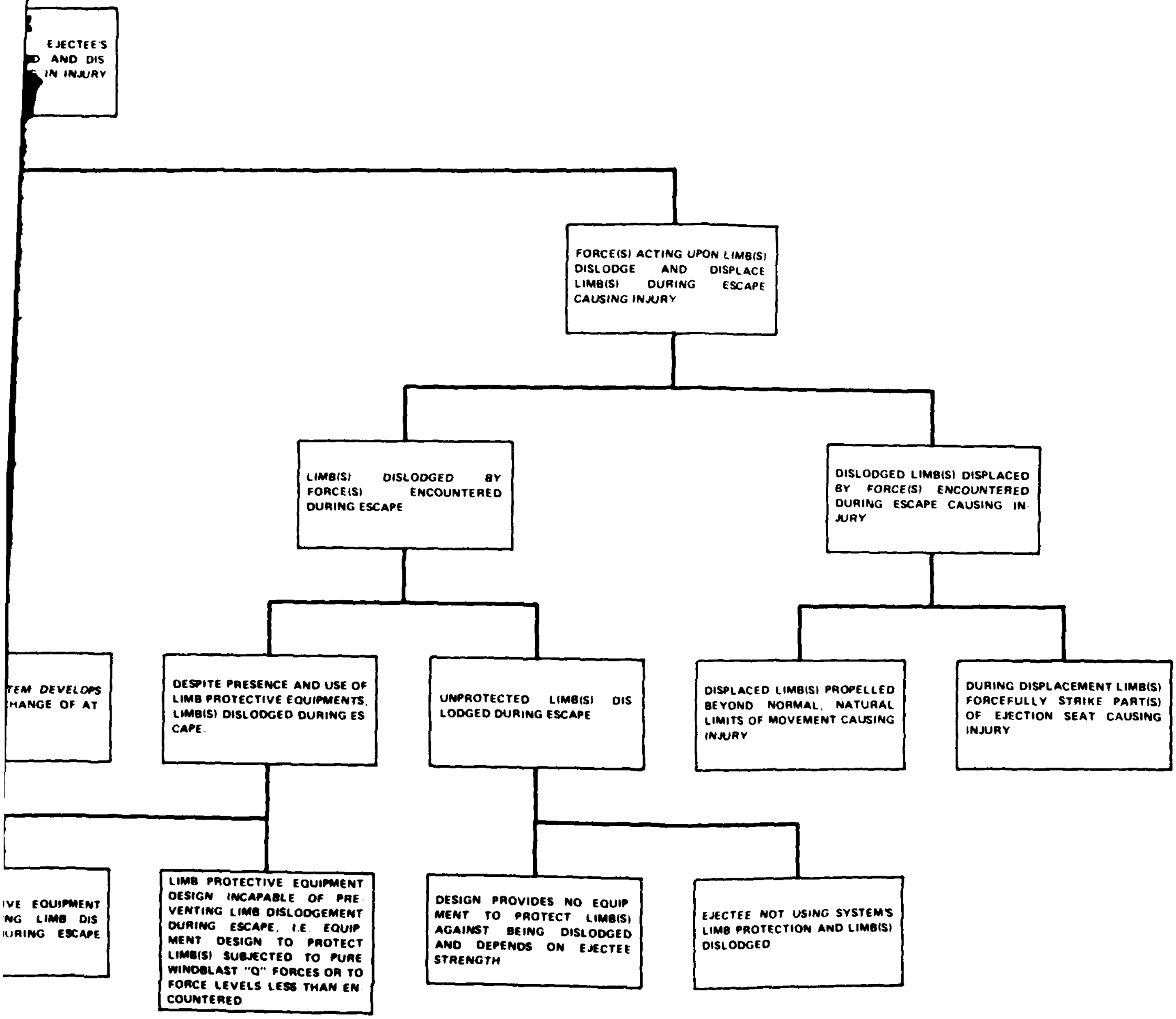
- Whether the limb movement is sufficiently rapid and extreme to exceed normal motion limits in a manner capable of overstressing joints, ligaments and muscles, particularly at the limb/torso interface.

Preliminary results of the Naval Weapon Engineering Support Activity's recently started evaluation of MOR data concerning the incidence of flail and flail injuries and the often associated windblast and tumble problems and injuries are presented in <u>An Evaluation of Flail, Windblast and Tumble Problems and Injuries Associated With Usage of U.S. Navy Aircrew Automated Escape Systems (AAES)</u>.

CAUSATION OF FLAIL-TYPE LIMB PROBL



PE LIMB PROBLEMS AMONG EJECTEES



Preliminary Analyses of Flail, Windblast and Tumble Problems and Injuries Associated with usage of U.S. Navy Aircrew Automated Escape Systems (AAES)

Myrtice Roberson, Charles Stokes, Larry Lewis, Frederick Guill

During ejection, the ejectee is subjected to a series of rapidly changing combinations of forces. These forces include forces resulting from:

- o aircraft maneuver (i.e., spin, rolling, yawing, etc.)
- o catapult boost
- o sustainer motor thrust
- o windblast (q force)
- o drogue opening and operation
- o parachute opening
- o operation of stabilizer components (DART, STAPAC, etc.)
- o operation of man-seat separation devices (bladders, separator rockets, etc.)
- o seat/man instability

The forces and the changes in the force vectors work to dislodge an ejectees's limbs and, once dislodged, to move the limbs about freely, sometimes injuriously.

Commonly, flail, windblast and tumble are thought of as high speed ejection problems; a form of windblast phenomena. An examination of U.S. Navy ejection data compiled from Medical Officer's Reports (MORs) for the period 1 January 1969 through 31 December 1979, suggests otherwise; that these phenomena can, and do, occur at even very low ejection airspeeds. The data, as shown in Tables I and II reveal that 83.2 percent of all non-fatal ejections occurred at airspeeds less than 300 kts. Of these low speed ejectees, 17.2 percent were reported to have experienced flail, windblast and/or tumble problems and 3.2 percent were reported to have sustained injuries attributed to flail, windblast and/or tumble. Nonetheless, despite the seemingly low incidence of these injuries among low speed ejectees, 65.3 percent of all reported flail, windblast and/or tumble problems (162 of the 248) and 39.0 percent of all flail, windblast and/or tumble attributed injuries (30 of the 77) occurred among these low speed ejectees.

Interestingly, flail, windblast and tumble problems occur frequently during ejections below 100 kts. Injury attributed to these causes is, however, infrequent for these lower speed ejections.

Even though flail, windblast and tumble are not uncommon problems and injury causal factors for ejectees, there are differences in the frequency of problems and in the frequency of injuries among the various ejection seat types used at given airspeeds. These differences could be expected to be related to differences in ejection seat design, i.e., type of stabilization provided, type of limb restraint provided and its usage, type and timing of man-seat separation, etc. Accordingly, the following seat groupings were utilized in organizing the ejection data for further examination:

Group	Seats	Group Common Characteristics
I	ESCAPACs I, IA-1, IC-2, IC-3	No drogue, DART stabilized for initial travel, bladder - induced man-seat separation before parachute deployment, no leg restraints.
II	ESCAPACs IF-3, IG-2, IG-3	No drogue, DART stabilized for initial travel, rocket - induced man-seat separation before parachute deployment with faster timing for all events, no leg restraints.
III	Martin-Baker MK5 Series	Ballistic catapult, 1.00 second drogue firing, 5 ft stabilizer drogue, 1.75 second TRM shackle release for parachute deployment before man-seat separation garter-type leg restraints.
IV	Martin-Baker MK7 Series	Reduced charge ballistic catapult with separate rocket sustainer motor, 0.50 second drogue firing, 5 ft stabilizer drogue, 2.00 second TRM shackle release for parachute deployment before man-seat separation, garter-type leg restraints.

Collectively these four groupings of ejection seats include 1,010 of the 1,135 U.S. Navy aircrew surviving inflight ejections accomplished clear of the aircraft during the period of 1 January 1969 through 31 December 1979 and, accordingly, afford the best available population sizes for analysis. The remaining U.S. Navy ejection seats are not readily amenable for grouping by common characteristics and, therefore, provide only small populations for analysis.

Table III and figures 1 through 4 provide detailed distribution data for the four seat groupings by ejection airspeed ranges for surviving ejectees, surviving ejectees who experienced flail, windblast and/or tumble problems, and surviving ejectees who sustained injuries attributed to flail, windblast and/or tumble. Tables IV through XII were developed to aid in planning detailed analyses to be conducted into flail, windblast and tumble phenomena provide comparative distributions of these survivor categories for selected groupings of the ejection airspeed ranges.

These preliminary data suggest the following:

(a) Concerning the change from Group I to Group II:

(1) 0-99 kts. Introduction of the newer ESCAPACs (Group II) may reduce the incidence of flail, windblast and/or tumble problems but increase the incidence of injuries attributed to these causal factors; suggesting that when these problems do occur with Group II seats that they are more severe than in the Group I seats.

(2) 100-299 kts. Introduction of the Group II seats may have increased slightly the incidence of flail, windblast and/or tumble problems and probably has increased the incidence of injuries attributed to these causal factors. Again suggesting that these problems in the Group II seats are possibly more severe than in the Group I seats.

(3) 300 + kts. Introduction of the Group II seats may have reduced the incidence of problems and injuries attributable to flail, windblast and/or tumble. Possibly noteworthy is the reduction in these rates between 250 and 400 kts. which suggests that the design changes may have modified the free flight characteristics of the Group II seats.

(b) Concerning the change from Group III to Group IV:

(1) 0-99 kts. Introduction of the Group IV seats may have increased the incidence of problems and possibly of injuries attributed to flail, windblast and/or tumble.

(2) 100-299 kts. Introduction of the Group IV seats may have increased the incidence of problems caused by flail, windblast and/or tumble with either no impact upon or slightly reducing the incidence of injury attributed to these causes.

(3) 300 + kts. Introduction of the Group IV seats probably has not changed the incidence of problems attributed to flail, windblast and/or tumble but may have increased the incidence of injury attributed to these causal factors.

The relative sizes of the populations make difficult, at this time, formulating firm statements concerning flail, windblast and tumble problems and injuries and their causation.. Groups I and IV predominate the data while Groups II and III are each only

approximately one quarter the size of I and IV, respectively. Groups I and III and Groups II and IV, however, represent comparable state-of-the-art ejection seats. Another factor compounding these difficulties is the tendency of flight surgeons to attribute windblast as the causal factor for limb injuries of an ejectee who experienced flailing and/or tumbling. As shown in the Table VII there are a few ejectees who were reportedly injured by flail, windblast and/or tumble at very low ejection airspeeds. In each instance below 100 kts the cause was listed as windblast even though flailing and/or tumbling problems had been experienced.

Figure 5 illustrates the tendency to attribute windblast as the causal factor for limb injury incurred by ejectees who have experienced flail and/or tumble problems.

Based upon the data presented herein and upon descriptions of limb flail, tumbling and windblast experiences furnished in survivor and witness narratives, it is planned to investigate these three types of problems as well as the injury causal factors in greater depth in an attempt to ascertain why and how they occur. Preparations currently are underway to expand this investigation with the hope that results will be available within eighteen to twenty four months.

TABLE I

DISTRIBUTION OF U.S. NAVY SURVIVING EJECTEES, THOSE EXPERIENCING FLAIL, WINDBLAST AND/OR TUMBLE PROBLEMS AND THOSE SUSTAINING INJURIES ATTRIBUTED TO FLAIL, WINDBLAST AND/OR TUMBLE BY SPEED RANGE (0-299 kts and 300 + kts).

1 Jan 69 - 31 Dec 79

	EJECTION	AIRSPEED (kts)	TOTAL
	0-299	300 +	
Number of Surviving Ejectees	944 (84.2%)	177 (15.8%)	1121 (100%)
Number surviving ejectees experiencing flail, windblast and/or tumble problems	162 (65.3%)	86 (34.7%)	248 (100%)
Number ejectees experiencing flail, windblast and/or tumble sustaining injury attributed to flail, windblast and/or tumble	30 (39.0%)	47 (61.0%)	77 (100%)

TABLE II

INCIDENCE RATE AMONG THOSE U.S. NAVY SURVIVING EJECTEES EXPERIENCING FLAIL, WINDBLAST AND/OR TUMBLE PROBLEMS, AND THOSE SUSTAINING INJURIES ATTRIBUTED TO FLAIL, WINDBLAST AND/OR TUMBLE BY SPEED RANGE
(0-299 kts. & 300 +)
(percent)

1 Jan 69 - 31 Dec 79

	EJECTION	AIRSPEED (KTS)
	0-299	300 +
Percent surviving ejectees experiencing flail, windblast and/or tumble	17.2 %	48.6%
Percent ejectees experiencing flail, windblast and/or tumble sustaining injury attributed to flail, windblast and/or tumble	3.2%	26.6%

FIGURE 5

PROBLEM:		INJURIES CAUSED BY:	NO. OF PEOPLE INJURED:
FLAIL	(46)	NO INJURY	33
		FLAIL INJURY	7
		WINDBLAST INJURY	6
		TUMBLE INJURY	0
WINDBLAST	(63)	NO INJURY	46
		FLAIL INJURY	0
		WINDBLAST INJURY	16
		TUMBLE INJURY	1
TUMBLE	(61)	NO INJURY	57
		FLAIL INJURY	1
		WINDBLAST INJURY	2
		TUMBLE INJURY	1
FLAIL/WINDBLAST	(41)	NO INJURY	11
		FLAIL INJURY	2
		WINDBLAST INJURY	24
		FLAIL/WINDBLAST INJURY	4
FLAIL/TUMBLE	(15)	NO INJURY	14
		WINDBLAST INJURY	1
		FLAIL/TUMBLE INJURY	0
TUMBLE/WINDBLAST	(10)	NO INJURY	10
		WINDBLAST INJURY	0
		TUMBLE/WINDBLAST INJURY	0
FLAIL/TUMBLE/ WINDBLAST	(12)	NO INJURY	5
		WINDBLAST INJURY	5
		TUMBLE/FLAIL INJURY	1
		FLAIL/WINDBLAST INJURY	1
NOT CODED	(5)	FLAIL INJURY	1
		WINDBLAST INJURY	3
		TUMBLE INJURY	1

TOTAL SURVIVING EJECTEES (TYPES 1 AND 5) WITH FLAIL/WINDBLAST/TUMBLE PROBLEMS: 248
TOTAL SURVIVING EJECTEES (TYPES 1 AND 5): 253
TOTAL FLAIL, WINDBLAST & TUMBLE INJURED EJECTEES: 77

TABLE III

Distribution of U.S. Navy Surviving Ejectees , Surviving Ejectees Experie
Ejectees Sustaining Injuries Attributed to Flail, Windblast And/Or Tu

SEAT GROUPS / EJECTION AIRSPEED	GROUP I			GROUP II			
	No. of Surv.	No. of FTW Prob	No. of FTW Inj	No. of Surv.	No. of FTW Prob	No. of FTW Inj	No. of Sur
0-49	28	9	0	7	1	1	-
50-99	20	2	0	6	1	1	4
100-149	57	9	0	16	3	1	31
150-199	67	10	1	18	5	2	22
200-249	89	25	3	19	7	3	26
250-299	32	10	4	4	2	0	19
300-349	18	11	4	6	0	-	9
350-399	9	6	3	5	3	1	4
400-449	2	2	1	1	1	1	3
450-499	5	5	4	2	2	2	3
500-549	2	2	2	-	-	-	-
550-599	-	-	-	-	-	-	-
600-649	-	-	-	-	-	-	-
TOTALS	329	91	22	84	25	12	1[illegible]

LE III

ng F Experiencing Flail, Windblast And/Or Tumble Problems, And Surviving

: By d/Or Tumble By Airspeed Ranges and Ejection Seat Groups

OUP		GROUP III			GROUP IV			TOTALS		
No. FTW	Inj	No. of Surv.	No. of FTW Prob	No. of FTW Inj	No. of Surv.	No. of FTW Prob	No. of FTW Inj	No. of Surv.	No. of FTW Prob	No. of FTW Inj
-		-	-	-	14	0	-	49	10	1
0		4	0	-	28	5	1	58	8	2
0		31	0	-	105	6	0	209	18	1
0		22	0	-	112	10	1	219	25	4
2		26	2	1	79	16	4	213	50	11
5		19	5	2	47	15	1	102	32	7
4		9	4	0	50	16	4	83	31	8
1		4	1	1	18	6	1	36	16	6
0		3	0	-	10	9	8	16	12	10
3		3	3	2	11	6	4	21	16	12
-		-	-	-	1	1	1	3	3	3
-		-	-	-	1	1	1	1	1	1
-		-	-	-	-	-	-	-	-	-
15	2	121	15	6	476	91	26	1010	222	66

GROUP I

INCIDENCE OF FLAIL/WINDBLAST/TUMBLE AND RELATED INJURY AS A PERCENT OF AIRCRAFT AIRSPEED

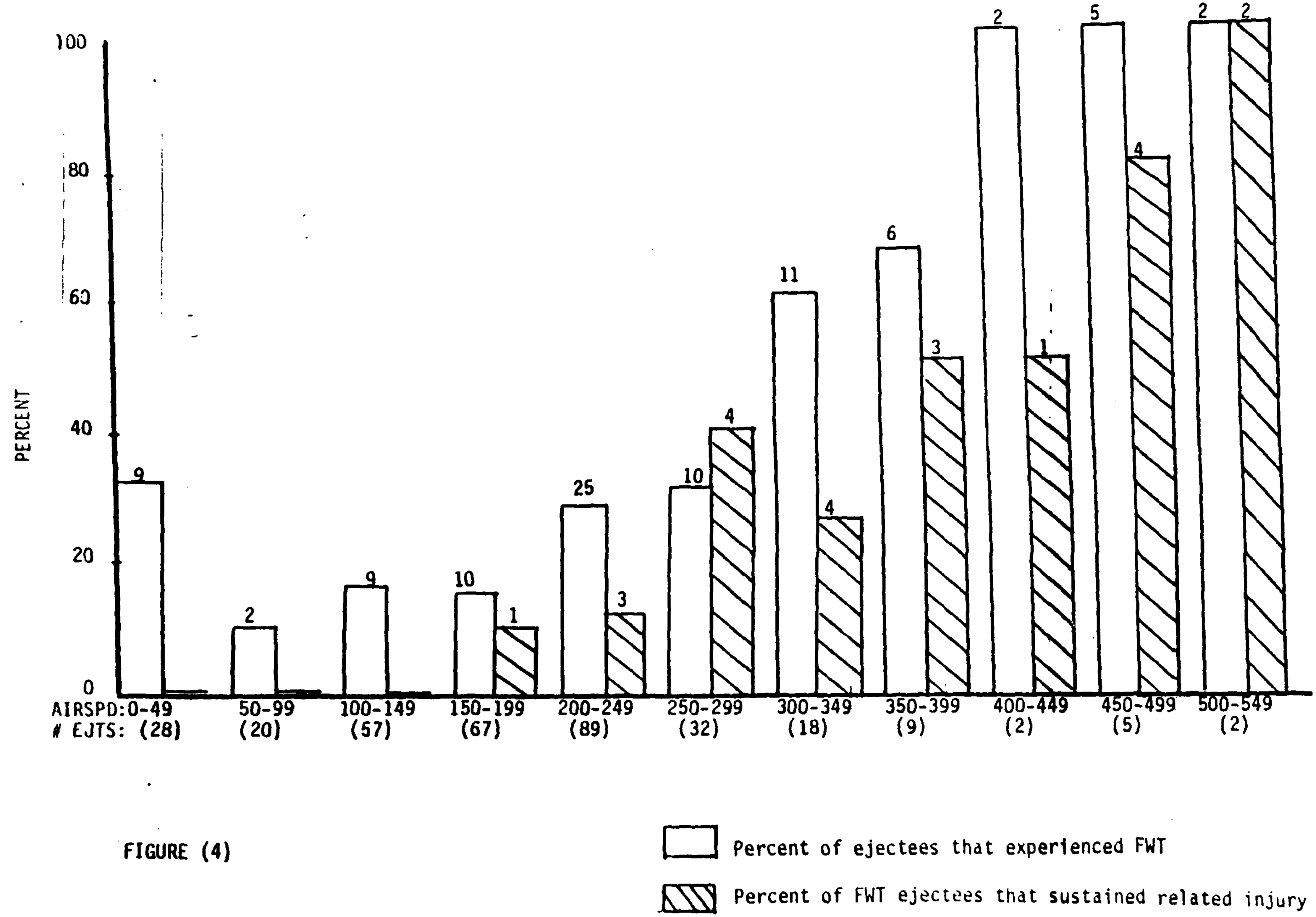


FIGURE (4)

INCIDENCE OF FLAIL/WINDBLAST/TUMBLE AND RELATED INJURY AS A PERCENT OF AIRCRAFT AIRSPEED

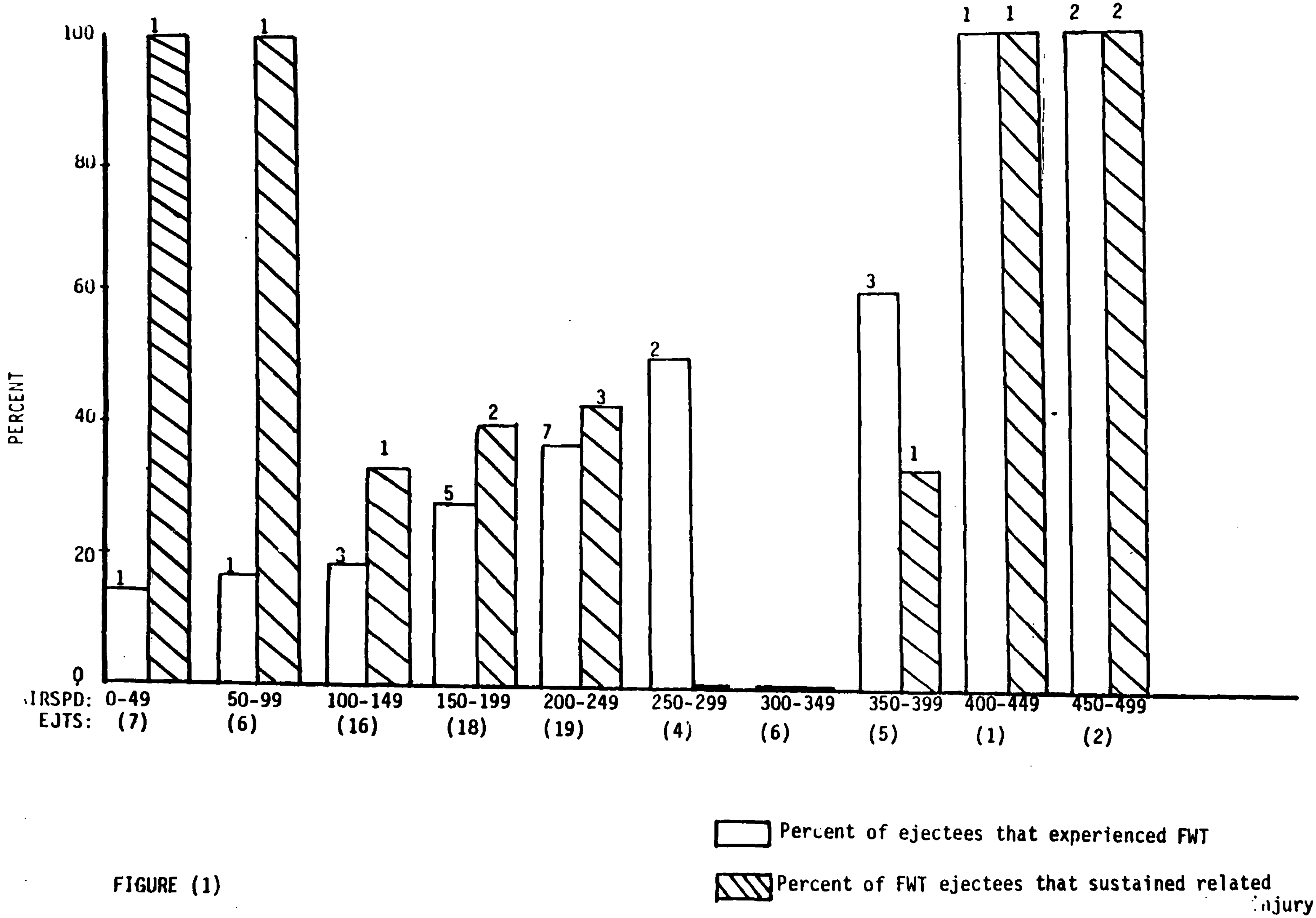


FIGURE (1)

GROUP III

INCIDENCE OF FLAIL/WINDBLAST/TUMBLE AND RELATED INJURY AS A PERCENT OF AIRCRAFT AIRSPEED

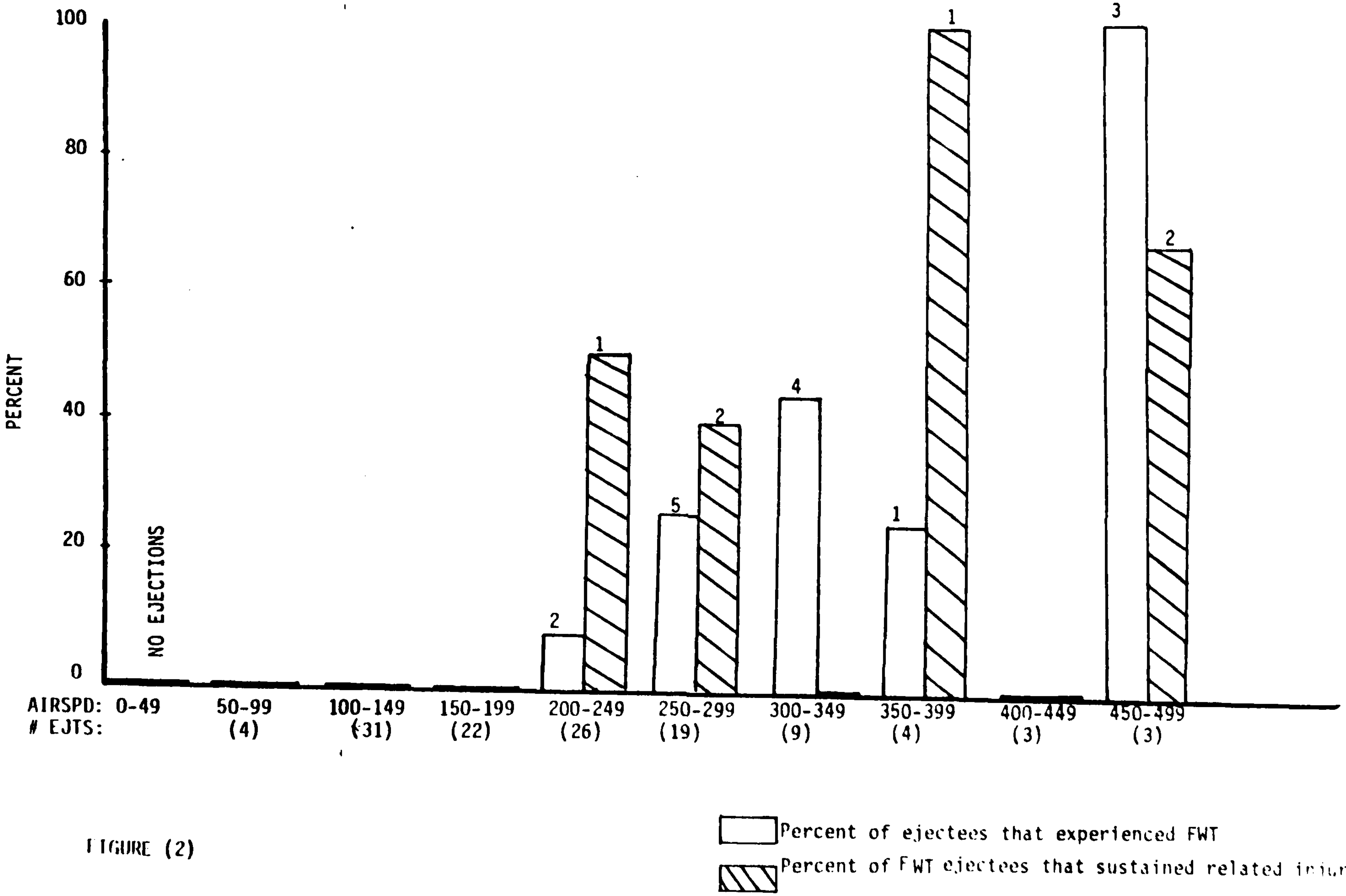


FIGURE (2)

GROUP IV

INCIDENCE OF FLAIL/WINDBLAST/TUMBLE AND RELATED INJURY AS A PERCENT OF AIRCRAFT AIRSPEED

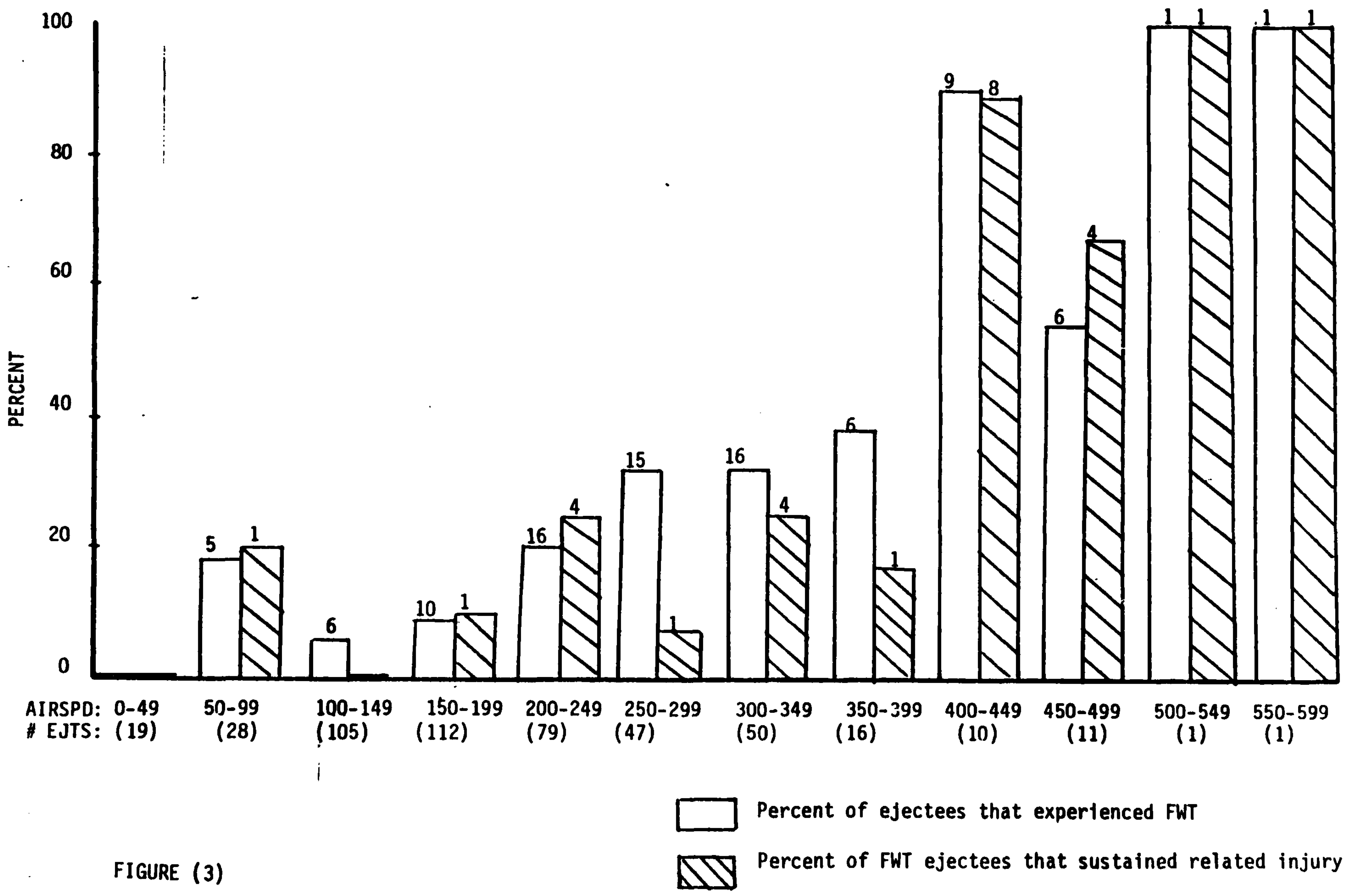


FIGURE (3)

TABLE IV

NUMBERS OF SURVIVING EJECTEES BY EJECTION
SEAT GROUP AND EJECTION AIRSPEED RANGE

1 Jan 1969-31 Dec 1979

EJECTION AIRSPEED RANGE (Kts)	EJECTION SEAT GROUPS				
	I	II	III	IV	TOTALS
0-49	28	7	-	14	49
0-99	48	13	4	42	107
0-299	293	70	102	385	850
100-299	245	57	98	343	743
300+	36	14	19	91	160
TOTALS	329	84	121	476	1010

TABLE V

NUMBERS OF SURVIVING EJECTEES EXPERIENCING FLAIL, WINDBLAST AND / OR TUMBLE PROBLEMS BY EJECTION SEAT GROUP AND EJECTION AIRSPEED RANGE

1 Jan 1969-31 Dec 1979

EJECTION AIRSPEED RANGE (Kts)	EJECTION SEAT GROUPS				
	I	II	III	IV	TOTALS
0-49	9 (32.1%)	1 (14.3%)	- (-)	Ø (0%)	10
0-99	11 (22.9%)	2 (15.4%)	Ø (0%)	7 (11.9%)	18
0-299	65 (22.2%)	19 (27.1%)	7 (6.9%)	52 (13.5%)	143
100-299	54 (22.0%)	17 (29.8%)	7 (7.1%)	47 (13.7%)	125
300+	26 (72.2%)	6 (42.9%)	8 (42.1%)	39 (42.9%)	79
TOTALS	91	25	15	91	

TABLE VI

NUMBER OF SURVIVING EJECTEES SUSTAINING INJURIES ATTRIBUTED TO FLAIL, WINDBLAST AND / OR TUMBLE BY EJECTION SEAT GROUP AND EJECTION AIRSPEED RANGE

1 Jan 1969-31 Dec 1979

EJECTION AIRSPEED RANGE (Kts)	EJECTION SEAT GROUPS				
	I	II	III	IV	TOTALS
0-49	Ø(0%)	1(14.3%)	- (-)	-(0%)	1
0-99	Ø (0%)	2(15.4%)	-(0%)	1(2.4%)	3
0-299	8 (2.7%)	8 (11.4%)	3(2.8%)	7(1.8%)	26
100-299	8(3.3%)	6 (10.5%)	3(3.1%)	6(1.7%)	23
300+	14 (38.9%)	4(28.6%)	3 (15.8%)	19 (20.9%)	40
TOTALS	22	12	6	26	

TABLE VII

DISTRIBUTION WITHIN EJECTION AIRSPEED RANGES OF SURVIVING EJECTEES
BY EJECTION SEAT GROUP
(per cent)

1Jan 1969-31 Dec 1979

EJECTION AIRSPEED RANGE (Kts)	EJECTION SEAT GROUPS				
	I	II	III	IV	TOTALS
0-49	57.1	14.3	-	28.6	
0-99	44.9	12.1	3.7	39.3	
0-299	34.5	8.2	12.0	45.3	
100-299	33.0	7.7	13.2	46.3	
300+	22.5	8,8	11.9	56.9	
TOTALS					

TABLE VIII

DISTRIBUTION WITHIN EJECTION AIRSPEED RANGES OF SURVIVING EJECTEES EXPERIENCING FLAIL, WINDBLAST AND/OR TUMBLE PROBLEMS BY EJECTION SEAT GROUP

(PERCENT)

EJECTION AIRSPEED RANGE (Kts)	EJECTION SEAT GROUPS				
	I	II	III	IV	TOTALS
0-49	90.0	10.0	-	0	
0-99	61.1	11.1	0	27.8	
0-299	45.4	13.3	4.9	36.4	
100-299	43.2	13.6	5.6	37.6	
300 +	32.9	7.6	10.1	49.4	
TOTALS					

TABLE IX

DISTRIBUTION WITHIN EJECTION AIRSPEED RANGES OF SURVIVING EJECTEES SUSTAINING INJURIES ATTRIBUTED TO FLAIL, WINDBLAST AND/OR TUMBLE BY EJECTION SEAT GROUP

(percent)

EJECTION AIRSPEED RANGE (Kts)	EJECTION SEAT GROUPS				
	I	II	III	IV	TOTALS
0-49	0	100	-	-	
0-99 -	0	66.7	-	33.3	
0-299	30.8	30.8	11.5	26.9	
100-299	34.8	26.1	13.0	26.1	
300 +	35.0	10.0	7.5	47.5	
TOTALS					

TABLE X

DISTRIBUTION WITHIN EJECTION SEAT GROUPS OF SURVIVING EJECTEES BY EJECTION AIRSPEED RANGE

(PERCENT)

EJECTION AIRSPEED RANGE (Kts)	EJECTION SEAT GROUPS				
	I	II	III	IV	TOTALS
0-49	8.5	8.3	-	2.9	
0-99	14.6	15.5	3.3	8.8	
0-299	89.1	83.3	84.3	80.9	
100-299	74.5	67.9	81.0	72.1	
300 +	10.9	16.7	13.2	19.1	
TOTALS					

TABLE VI

DISTRIBUTION WITHIN EJECTION SEAT GROUPS OF SURVIVING EJECTEES SUSTAINING INJURIES ATTRIBUTED TO FLAIL, WINDBLAST AND/OR TUMBLE BY EJECTION AIRSPEED RANGE

(PERCENT)

EJECTION AIRSPEED RANGE (Kts)	EJECTION SEAT GROUPS				
	I	II	III	IV	TOTALS
0-49	0	8.3	-	-	
0-99	0	16.7	-	3.8	
0-299	36.4	66.7	50.0	26.9	
100-299	36.4	50.0	50.0	23.1	
300 +	63.6	33.3	50.0	73.1	
TOTALS					

AD-A172 051 AIRCREW AUTOMATED ESCAPE SYSTEMS (AAES) IN-SERVICE USAGE DATA ANALYSIS PROGRAM(U) NAVAL AIR SYSTEMS COMMAND WASHINGTON DC F C GUILL FEB 82 3/4

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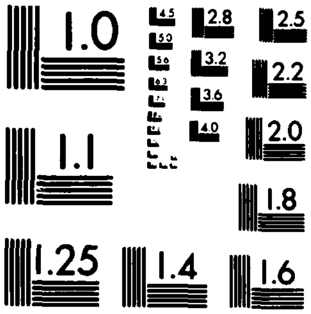

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NATIONAL BUREAU OF STANDARDS-1963-A

TABLE XII

DISTRIBUTION WITHIN EJECTION SEAT GROUPS OF SURVIVING EJECTEES EXPERIENCING FLAIL, WINDBLAST AND/OR TUMBLE PROBLEMS BY EJECTION AIRSPEED RANGE

(PERCENT)

EJECTION AIRSPEED RANGE (Kts)	EJECTION SEAT GROUPS				
	I	II	III	IV	TOTALS
0-49	10.0	4.0	-	0	
0-99	12.1	8.0	0	5.5	
0-299	71.4	76.0	46.7	57.1	
100-299	59.3	68.0	46.7	51.6	
300 +	28.6	24.0	53.3	42.9	
TOTALS					

MISHAP INVESTIGATION/REPORTAGE

THE FLIGHT SURGEON'S REPORT (FSR) FROM A DATA USER'S VIEWPOINT

Frederick C. Guill

INTRODUCTION

A quick scan through the sixteen (16) blank forms (fourteen (14) of which have on their reverse instructions concerning how to complete the blanks) comprising the basis for preparing Flight Surgeon's Reports (FSRs) concerning aviation mishaps undoubtedly is sufficient to dismay many who either face the immediate task or may potentially face the task of preparing an FSR. The topics included in the FSR cover a broad range and, in most instances, with a requirement for considerable detail concerning each. Undoubtedly those viewing the form with the realization that someday the task of preparing the FSR may be theirs question the validity of the request for so great a quantity of information. They might even wonder if the FSR perhaps represents another example of "make work" which when completed eventually disappears in musty, dusty files or into a computer never to be meaningfully used. And, undoubtedly, they might wonder how and where, considering the wide range of the questions and the large and constantly changing Navy inventory of escape systems, flight garments and equipments, and survival garments and equipments, does one obtain the technical expert assistance required to assure the completed FSR's accuracy.

A user of the data obtained from FSR's, of course, has considerably different concerns. These include concern with respect to the accuracy and completeness of the data and how to obtain sufficient detail to permit proper interpretation of the report. The user also soon finds that he is extremely concerned regarding the tendancy, understandable though it may be, for FSR preparers to furnish what might be termed "classical" responses for many FSR blanks, particularly those requesting causal factor identification for injuries and for problems. The user also soon becomes perturbed concerning the system or equipment operation knowledge of the preparers which ranges from exceptionally good to poor. For the most part, users of FSR data are attempting to learn how well or how poorly systems and equipment worked when required; how well or how poorly people responded to situations and whether training, systems and/or equipments were appropriate and useful or inappropriate and harmful; and the role that environmental conditions and/or personal factors may have had in producing, ameliorating or exacerbating the situations. The data are reviewed and analyzed in hopes of enhancing the safety and effectiveness of the Navy's aviation community personnel, be they pilots, flight officers, enlisted aircrew, ground crew, and/or maintenance personnel.

The FSR, as was its predecessor, the MOR (Medical Officer's Report), is an attempt at balancing the legitimate concerns of those about whom the report is written, of those preparing the report and of those using the report or extracts and compilations of FSR data. In January 1981 the Naval Safety Center convened a meeting at its headquarters in Norfolk, Virginia, to review the FSR format and content requirements. Attending the meeting were fleet flight surgeons and aviation physiologists representing the preparing community (and to some extent the community of aviation personnel likely to be report subjects) and user community flight surgeons, aviation physiologists, data encoders, and engineers. The formal sessions were long with extensive discussion of the various viewpoints and concerns. The evening drafting sessions involving small groups also were quite long with considerable discussion. Users constantly and properly were required to justify their requests for information and, in many instances, eliminated requests or combined requests. A major effort was mounted to improve the FSR format to make the preparer's and reader's tasks easier.

Resolution of system and equipment in-service problems requires three separate but interrelated activities. Information has to be obtained concerning the conditions and results of the in-service usage of the system or equipment; that information has to be analyzed and interpreted, often through reference to previously collected similar data for that and/or similar systems or equipments, to define as thoroughly and accurately as feasible the problem, including probable causal factors and mechanisms; and, finally, the problem definitions and related information must be furnished to those organizations capable of, and responsible for, initiating corrective actions for the particular system or equipment.

The almost exclusive source of information concerning how well or how poorly aircrew automated escape systems (AAES) and associated aircrew life support system (ALSS) equipments perform under emergency conditions is the FSR prepared by the aeromedical community for specific categories of aviation mishaps. Occasionally that information is supplemented with information gleaned from the Mishap Investigation Report (MIR) (previously the Aircraft Accident Report (AAR)) or by laboratory investigations involving recovered articles and equipments. The information obtained from these sources has been for years, and continues to be, used to define the operational environments and emergency environments to which AAES and ALSS are subjected and under which they must function correctly and to define the problems being encountered with AAES and ALSS in daily and emergency usage. These definitions, in turn determine whether attempts will be made to develop in-service fixes or to replace AAES and ALSS performing less than satisfactorily. These definitions also are employed to define the design performance, test, and evaluation requirements of specifications employed in contracts for acquiring future AAES and ALSS inventories. These definitions and the underlying data also serve to guide the AAES and ALSS research aimed at providing new technology for enhancing the safety and effectiveness of the Navy aviation community's personnel.

Thus the AAES and ALSS research, development and acquisition community, both Navy and industry, wants and urgently needs accurate, complete FSR data concerning these equipments and the conditions of their usage and their successes, problems and failures to enable improvements to be made. These needs underlay the establishment of a formal system for acquiring and analyzing rigorously the FSR information (later to be supplemented with 3M and similar maintenance data) under Naval Air Systems Command tasking to the Naval Weapons Engineering Support Activity, Washington, D.C., with data and assistance furnished by the Naval Safety Center, Norfolk. This project is introduced in a separate paper entitled U.S. Navy Aircrew Automated Escape System (AAES) In-service Usage Data Analysis Program. The Work Unit establishing this project is furnished within the collection of papers and information provided conference attendees.

FSR INFORMATION NEEDED AND USED BY AAES AND ALSS COMMUNITY

When attempting to explain something as long and as detailed as the FSR forms, one faces two opposing dangers with respect to communicating with one's audience. Explaining in too great detail, covering all items, often results in an overly long explanation which will include many items which individual members of the audience might consider obvious and not requiring explanation. Yet, if one should pass over or incompletely explain items, someone in the audience might not understand that item and believe an explanation is necessary. In either case, there is risk of losing one's audience either through boredom or through an inability to jump the deliberate gaps.

This written explanation provides an item-by-item explanation of the FSR data requests which can fulfill the data needs of the AAES In-service Usage Data Analysis Program in identifying and defining for the Crew Systems Division (AIR-531), Naval Air Systems Command problems being experienced with, or deficiencies discovered in, the Navy's AAES and associated ALSS during flight operational uses and during emergency uses. For ease of organization, the explanations are provided on a page-by-page basis, sequentially for each page, as depicted by the highlighting of the FSR forms, figures 1 through 16.

OPNAV 3752/3 (page 1 of 1) (Fig. 1)

Section I. General Information

Block 3. Mishap Category:

This identification is used in the basic sorting of the cases for preliminary analyses and in preparation for subsequent routine and special data analyses.

Block 6. Model A/C

This data is employed both in initial sortings of the cases and as a means for cross checking the validity of other data presented in the completed FSR. Eventually it is planned that limited flight type data formulations will be included in the automated data analyses and the data presented in this block will help trigger the use of those formulae.

Block 7. BUNO

Future plans for the data anlaysis program include experimentation in combined analyses of FSR and 3M, as well as other sources of maintenance data, and FSR, 3M and configuration (changes incorporation data, etc.) data. Thus the aircraft BUNO will be necessary to permit cross correlation of the data sources.

Block 8. No. of Occupants

Since Privacy Act problems make undersirable that the Data Program acquire and hold the Block 9 (Name) information of the individuals involved, this data is employed to assure that the records used by the Data Program cover the correct number of individuals. This of course is not a problem in single seat aircraft, but in multi-seat aircraft it has at times been a problem.

Block 10. Sex

This is a new data item reflecting the new and growing presence of female naval aviators. This information will permit analyses of ejection data for female aviators both to spot danger signals and to calm doubts concerning female safety during ejection and subsequent survival phase of escape.

Block 15. Injury Classification

This constitutes another basis for preliminary sorting of the cases.

Block 17. Terrain Clearance

This data concerning the conditions when the emergency began is used to identify the frequency of occurrence of major emergencies outside escape system performance envelopes, to identify the needed escape system performance envelope capabilities for present and future Navy aircraft to minimize loss of aircrew lives, to ascertain the consequences of delays between emergency onset and escape initiation on improving or

worsening aircrew ability to escape and survive, and, also, for many other purposes concerning the use and non-use of the escape system. Even in cases in which escape was not attempted, knowledge of the probable terrain clearance and/or terrain profile at emergency onset may prove valuable in defining performance requirements for equipments to alert the aircrew concerning their danger, actions needed and/or need to eject.

Block 24. Airspeed at Time of Mishap

This data has an independent function similar to that of the data requested by Block 17 (Terrain Clearance). In addition, the information often is combined with the Block 17 and Block 6 (Model A/C) information for analyses.

Section III. Narrative Account of Mishap

The narrative account of a mishap, the events and conditions preceding, during and following it, is an extremely critical aspect of an FSR. Properly written, using the balance of the FSR as a form of checklist, the narrative ties together the information presented throughout the FSR, clarifying the case for the analyzer. Poorly developed and written the narrative can reduce the value of the information presented elsewhere in the FSR. The narrative is examined under the Data Program to corroborate, expand and clarify the information presented in the many blocks of the FSR. Parts of the narrative are, upon occasion, employed to illustrate in a meaningful manner problems, deficiencies and/or issues of interest to, or requiring action by, the Crew Systems Division and its field activities.

OPNAV 3752/4 (page 1 of 2) (Fig. 2)

Section I. General

Blocks 1 through 6.

These data provide information concerning the impact of mishaps upon aircrew readiness for duty and, thereby, on the Navy's mission readiness. The data also provide an initial basis for developing mishap cost data with respect to the personnel aspects.

Block 7. Duration of Altered State of Consciousness

A potentially important problem requiring careful collection and reportage of information is the affect of escape conditions, systems and equipments upon ejectee consciouness. Periods of unconsciousness, dazedness, dizzyness, and/or inability to function effectively due to mental impairments among survivors whether over land or over water; whether cleared prior to

surface contact, continuing through surface contact, or occurring after surface contact may be warnings concerning operation of systems and/or equipments under specific or all escape conditions which might require corrective action. Transient problems of this nature under certain circumstances can, of course, cause fatalities and therefore need to be carefully identified and reported with explanations. Even though an ejection may occur over land, altered state of consciousness information is important for it might aid in understanding, for example, high overwater ejection fatality rates. This poses a potential problem for the FSR preparer since the surviving ejectee, particularly one who ejected over land, may not be sufficiently concerned to remember and/or mention a brief period of unconsciousness, dazedness, dizzyness, etc. Nonetheless this data is extremely critical for analyzing how well or how poorly AAES and associated ALSS equipments are performing.

Section II. Injuries Incurred During Mishap

Blocks 1 through 5.

Careful and complete reportage of injury diagnoses and body part locations aids in developing system/equipment injury relationships. Injury cause is a controversial data item which can cause, and has caused, considerable effort and resource expenditure in attempts to prevent recurrence of particularly severe injuries or frequent injuries. When the factor(s) advanced as the cause(s) for particular injuries/injury patterns has been incorrect, the efforts and resources expended generally have not produced means for eliminating or ameliorating the factors and/or their consequences. Therefore, to help ensure the Navy's limited ALSS and AAES resources are employed beneficially to resolve problems producing injuries and to guard against these resources being wasted, it is important that the FSR preparer exercise care in stating causal factors. (Note that the instructions for identifying cause require a brief description of "the mechanism of injury, i.e., 'Hyperflexion', 'Blunt Trauma', etc." and caution that describing "external factors which affected mechanism of injury" should be done "only if those factors can be established with a reasonable degree of confidence" and that the "means for establishing that confidence, i.e., 'paint from seat found on helmet', 'aircrew statement', 'rescuer's statement'" should be described.) All of these data are analyzed for patterns of occurrence for particular groups and combinations of systems and equipments, as well as for the individual systems and equipments in an attempt to ascertain likely causal factors, likelihood of recurrence and overall significance to survival and/or lengthy groundings of Navy aircrew.

The ICD (International Classification of Diseases) Code (a new request) is requested in an attempt to help standardize and thereby clarify the injury reportage by the many preparers of FSRs. The Injury Severity Code serves as an aid in assessing the significance of reported patterns of injuries.

OPNAV 3752/4 (page 2 of 2) (Fig. 3)

Section VIII. Injury Profile

It is planned that eventually the Data Program will have the capability of superimposing these injury location sketches as a further step in ascertaining injury patterns and causes.

Section IX. Remarks

To enable analyzers to ascertain complete injury patterns for comparison with those reported in other ejections and determination of likely causation of recurring injury patterns, it is especially important that all injuries be completely recorded. Data will be used as indicated for Section II (Injuries Incurred During Mishap).

OPNAV 3752/5 (page 1 of 1' (Fig. 4)

Data of specific interest to the Data Program on this page include:

2.E. Inadequate Knowledge of ALSS

3.C. Workspace Incompatibility
3.D. Anthropometric Incompatibility
3.E. Confusion of Controls, Switches, etc.
3.I. Inadvertent Operation
3.K. Personal Equipment Interference
3.L. Inadequate Crashworthy Design

4.C. Disrupted Communications
4.D. Poor Crew Coordination

5.A. Acceleration/Decceleration Forces
5.B. Decompression
5.C. Vibration
5.D. Heat/Cold
5.E. Windblast
5.F. Weather
5.G. Visibility Restriction
5.H. Smoke, Fumes in Cockpit
5.I. Air Turbulence

6.A. Poor Physical Conditioning
6.D. Sleep Deprivation
6.E. Missed Meals
6.F. Medication(s) (self-prescribed)
6.G. Medication(s) (MD-prescribed)
6.H. Altered Consciousness
6.I. Disorientation, Vertigo
6.O. Hypothermia
6.P. Hyperthermia

specifically as the data potentially relate to usage, non-usage, mis-usage of AAES and/or ALSS and to survival, death or injury of the aircrew. Analyses of these data will focus primarily on patterns and will also use some of these for further grouping and/or for flagging the need to search FSR hard copies for specific additional data for subsequent analyses. From time-to-time other data items on this page might be subjected to special analyses.

OPNAV 3752/6 (page 1 of 2) (Fig. 5)

Current Data Program plans do not include analysis of this information, since it properly is outside the purview of the tasking assignment. The data requested is in accordance with the request of physiologists attending the FSR meeting in January 1981.

OPNAV 3752/6 (page 2 of 2) (Fig. 6)

Section III. Anthropometric Data

Blocks A through I describe specific anthropometric data normally available for aviators as a consequence of measurements made during physicals. These data will be examined for pattern relationships with aircrew injury and/or problems during egress and during subsequent phases of escape. Problem categories which will be checked include tumbling occurrences, certain types of injuries and problems, toe strikes and other body or equipment contact with cockpit during egress, etc. One type of anthropometric data not normally obtained during physicals and therefore not requested in this Section but which may prove critical in view of the increased female naval aviator population and increased numbers of small and very large male naval aviators is the Buttock-Popliteal Length. (An overly short B-P Length could result in pelvic rotation and submarining or lower leg and foot extension outside of the design ejection envelop with increased chance for foot strikes during egress. A very large B-P Length could result in a long thigh overhang beyond the end of the thigh support with consequent pelvic rotation and submarining. Pelvic rotation and/or submarining which result in misalignment of the spinal column have long been suspected causes of vertebral compression fractures and have on at least one occasion during human tower testing been the most probable causal factor.) As a substitute, "F. Buttock-Knee Length", will be examined for potential relationship with types of injuries and problems.

Additional anthopometric data concerning ejectee hand breadth when grasping (bare and gloved) and maximum and minimum grasp diameter (bare and gloved) probably will be sought later by questionnaires to ascertain the potential role that these grasping hand dimensions which are not normally described in collections of anthropometric data might play in the prevention of and production of upper limb flailing. (Refer to the enclosed paper Preliminary Generalized Thoughts Concerning Ejection Flail Phenomena concerning preliminary thoughts regarding potential factors, including anthropometric considerations, which might be contributing to the incidence of flail.) It is anticipated that other anthropometric data not furnished by FSRs also might be sought through questionnaires when analyses of FSR data suggest a potential involvement either in producing or in preventing specific injury patterns and/or problems.

OPNAV 3752/7 (pages 1 and 2 of 2) (Figs. 7 and 8)

In order to reduce the recurrence of problems occurring in FSRs and MORs in the past, wherein information concerning aircrew life support systems equipments, especially the normal, flight and survival garments worn by aircrew, has not been furnished unless circumstances such as problems with the particular equipment, equipment absence made conspicuous by the conditions attendant to the escape and/or the survival, or the particular equipment performed a major role (eg., parachute, ejection seat) and a line was identified by the form for the information; the list of equipments on these pages was made more complete to serve as a check list. This general lack of information concerning flight and survival garments worn by the aircrew during ejections largely precludes any meaningful analyses concerning the ability, or inability, of present (and past) inventories of these equipments to perform successfully during and after an ejection. To some degree, of course, reports of failures shed some light on the issue. However, without information concerning the exposure that these equipments receive to the full spectrum of escape and survival conditions, whether or not the equipments sustain damage, it is impossible to ascertain how frequently problems occur and whether the equipment generally performs well except under limited sets of conditions or whether it generally performs poorly, etc. In turn, definition of the problem and of the required design performance suffer. Thus a fix or replacement equipment might not solve the problem completely and/or may introduce problems not previously experienced. In addition, these data eventually will result in the Data Program having ejected weight computed automatically based upon the cited equipments and then inserted

into formulae concerning aircraft dynamics and ejection seat functioning to produce estimates concerning whether escape was initiated in or out of the system's performance envelope, and stability issues and other aspects of system functioning. These data will also be employed to examine their relationships (presence, absence, usage, non-usage, etc.) with injuries and problems occurring during escape or survival phases. Care will be required to ensure that all equipments which were present are recorded and properly (accurately and completely) identified and that usage and problems are noted and described (see decision tree presented separately).

OPNAV 3752/8 (page 1 of 2) (Fig. 9)

Section 1. Location in Aircraft

These data locate the specific individual in a specific locale for multi-seat aircraft. Since time delays, trajectory divergence and other critical AAES/ALSS factors often vary with seat location, accurate "location in aircraft" data is critical to analyses. Eventually the Data Program will automatically select the proper variables for the specific seat location and insert these into the formulae for automatically computing ejection trajectory for the conditions reported.

Section II. Escape

These data define whether an escape was attempted and, if so, what type of escape, i.e., whether it was intentional, and in what sequence among multi-crew it was accomplished. These data are included in various analyses looking for injury, fatality and problem patterns. In many instances, data analyses would be aided by narrative descriptions of the information bases used by the FSR preparers for selecting specific categories of escape method and intent.

Section IV. Terrain of Parachute Landing or Crash Site

These data concern the site at which the individual aircrew reached the surface. Since many forms of post-egress injury relate to parachute landing terrain, these data are examined for relationship to patterns of injury, fatality and problems.

OPNAV 3752/8 (page 2 of 2) (Fig. 10)

Section V. Aircraft Parameters at Time of Escape

These data are currently analyzed for their relationships with injury, fatality and problems. Eventually the planned automatic analysis will combine these data with ejected weight (generated from data presented on OPNAV 3752/7), aircraft model, seat type, location in aircraft, etc., to produce estimates concerning whether escape was initiated within the escape system performance envelope, escape system dynamic stability behavior, escape system performance envelope capabilities needed, relationship of conditions attendant to escape with injury and problem patterns, etc. This data will also be compared with the data requested in Blocks 17 (Terrain Clearance) and 24 (Airspeed at Time of Mishap) of OPNAV 3752/4 to ascertain the affects of delays following the onset of various types emergencies upon aircrew safety.

Section VI. Egress Problems

These data are examined for patterns within individual seat types and seat families or with specific equippage configurations. In many instances, wherein details are known or information possibly related to the problems encountered is known, narrative comments will be exceeding helpful. This aspect is discussed in greater detail in a later section of this paper.

OPNAV 3752/9 (page 1 of 2) (Fig. 11)

Section I. Time From Emergency Until Escape Attempt Was Initiated

This information helps in the analysis of escape survival and fatality rates and when examined in conjunction with the information requested in Blocks 17 (Terrain Clearance) and 24 (Airspeed at Time of Mishap) of OPNAV 3752/4 and Section V (Aircraft Parameters at Time of Escape) of OPNAV 3752/8 and Section II (Delay In Initiating Escape Due To:) below, provides considerable insight concerning the types of emergencies requiring aircrew escape, the conditions attendant to such emergencies, and the rapidity with which those conditions deteriorate. In turn these types of information are needed to assure that required AAES design performance provide aircrew safe escape for the broadest range of manned aircraft mishaps.

Section II. Delay In Initiating Escape Due To:

Many escapes are delayed, some sufficiently so as to make doubtful the success of any attempt at escape. Careful documentation of the causes for delay is important in terms of potential impact upon AAES future design requirements and upon aircrew training. This is another area in which a narrative description of the bases for the FSR preparer's selection can be helpful.

Section III. Protective Helmet/O_2 Mask

Over the years helmet/oxygen mask loss has been a major concern. There is considerable confusion and controversy concerning both the frequency of loss and the possible causes for the losses. Assessment of the problem significance and resolution of the causal factors is dependent upon accurate reportage of helmet type and configuration (OPNAV 3752/7, lines 1 through 1.d.), oxygen mask type and configuration (OPNAV 3752/7, lines 3, 3a and 3b) (with careful attention given to correctly identifying the oxygen mask retainer fittings type/configuration, i.e., butterfly, bayonet with two straps, angled bayonet with one strap, etc.) (Figures 17 through 20) and the information requested in this section. Particularly desirable is information concerning whether the helmet and/or oxygen mask were recovered and if so, a narrative description of the equipment's recovered condition and configuration (i.e., helmet recovered without mask, chin strap and pads; oxygen mask recovered without helmet but with retainer and retainer fittings; helmet and mask recovered connected by left bayonet mask retainer fitting, chin strap and nape strap intact and connected; etc.)

Section IV Ejection Envelope

This has always been a complex question to answer, moreso than probably most people, including the preparers of MORs and FSRs, realize. The effects of descent rate, attitude, speed, rates of attitude change, aircraft accelerations, ejected weight, to identify only the more obvious, often require computer simulation to ascertain. If the ejectee is not recovered under a fully blossomed parachute and there was no indication of AAES malfunction, one has a good indication of an out-of-envelope escape attempt, yet not uncommonly even these are listed as in envelope attempts. If a full parachute is achieved, then, probably, the escape was attempted within the AAES performance envelope. If the parachute was deploying or filling when the ejectee impacted the surface and there was no indication of AAES malfunction, probably the escape attempt was inititated outside the envelope. However, there can occur various types of mal-

functions which leave no obvious evidence as, for example, overly long time delays. Other types of malfunctions such as operation in a back-up mode and not primary mode often are detectable only through careful laboratory analysis of all of the potentially affected parts as undisturbed as possible from their recovered condition. After the Data Program achieves the fully automated integration of aircraft conditions, AAES performance, ejected weight, etc., for analyzing escape attempts, this question will be resolvable with far less guesswork.

Section V. Removal of Aircraft Canopy

This information helps define, on occasion, the presence of problems, and helps in special groupings and analyses to ascertain the effects upon safe escape of the several canopy modes. Note in particular under Block C (Removal) lines 4, 5 and 6 ("Ejected Through Canopy", "Complete Cutting of Glass", and "Partial Cutting of Glass", respectively). These were added to reduce potential confusion concerning what is meant by, or intended to be meant by "through canopy". Ejection through the canopy means that seat and ejectee broke through otherwise intact canopy glass. Complete cutting of glass describes the case where the canopy frame is not jettisoned but the glass is cut/shattered/fragmented by an explosive charge so that seat and ejectee pass through an essentially empty canopy frame during egress from the aircraft. Partial cutting of glass describes use of explosives (at present) to weaken or partially break out sections of the canopy glass to reduce resistance to passage of seat and ejectee through the glass. (This selection may also be used to describe partial operation of a system designed to completely cut the glass but which through malfunctioning leaves large glass sections in place which were removed by the seat. In the event it is so used a narrative description of the evidence forming the basis for the selection decision would be helpful for the analyzer.)

Section VI. Method of Ejection Initiation

This information is useful in analyzing flail incidence and severity, access to specific handles, which individual in multi-place aircraft initiated escape, system free windstream stability, and other factors affected by "method of ejection initiation" which might be and/or often are alleged to affect ejectee safety.

Section VII. Body Position at Ejection (As Compared To Optimal)

This information also is useful in analyzing flail incidence and severity (i.e., elbows), and the incidence and severity of other injuries, especially vertebral. Narrative statements concerning the bases for selection would be useful. It should be noted by FSR preparers that injury, for example vertebral compression fracture or paravertebral muscle strain, does not per se indicate non optimal body position.

Sections VIII. Position of Ejection Seat, IX. Method Of Separating Man From Seat, and X. Method of Deploying Parachute

This information usually is examined for evidence of malfunction or possibly non-standard system configuration, especially since the last two data types are pre-determined by system design unless there is a malfunction.

Section XI. Parachute Opening Shock

Information from this section is used as a gross indicator of possible injury potential and for gross comparisons between systems used under similar ejection speeds, descent rates, attitudes, and ejected weights, and between similar probable parachute pack opening, full line stretch, etc., airspeeds and altitudes. Due to the qualitative nature of the data from individuals not accustomed to parachuting, these data can only be used for gross comparisons and gross indications but, nonetheless, are of value in assessing likelihood of adverse impact upon ejectee safety.

Section XII. Oscillations

Oscillations can induce, and have induced, among ejectees motion sickness, can cause, and have caused, ejectee entanglement with suspended equipments, can lead and probably have led, to parachute landing injuries which otherwise might be avoided. The 4-line release was introduced in part as a means of reducing the incidence and severity of ejectee oscillations while descending under a parachute and to thereby reduce the likelihood of oscillation induced problems.

Sections XIII. Parachute Damage and XIV. Cause of Parachute Damage

Parachute damage not caused on surface contacts can be valuable in assessing opening shock, system malfunctions, and ejectee descent rate at surface impact. Ground damage can help in assessing the dragging potential and other potentially injurious ejectee-surface interactions for specific escapes and for various types of landing sites and sets of landing site conditions.

OPNAV 3752/9 (page 2 of 2) (Fig. 12)

Section XV. Direction Faced at Parachute Landing With Respect to Horizontal Travel

This information will be reviewed for indications of potentially adverse effects upon ejectee safety.

Section XVI. Landing Conditions

This information will be examined for evidence of ejectee landing injuries and/or problems.

Section XVII. Canopy Deflation Pockets (Water Landing Only)

This information will be examined in conjunction with that presented in Section XVI (Landing Conditions), this page, and Section XII (Survival Problems Encountered by This Person) of OPNAV 3752/10, especially 01 (Inadequate Flotation Gear), 05 (Entanglement (Parachute)), 06 (Dragging (Parachute)), 07 (Parachute Hardware Problem), and 09 (Pulled Down by Sinking Parachute) to ascertain types, frequencies and severities of problems encountered by ejectees during and after landing in water.

Sections XVIII. Sequence of Actions Accomplished Before Landing, and XIX. Sequence of Actions Accomplished After Landing

This information is useful, when compared to probable parachute inflation altitude and speed, to help ascertain how well ejectees are able to function, how well they are able to prepare

for landing, and how well they are able to function after landing to enhance their survival. It is especially important information for over water ejections but is also important for ejections occurring over land (the overland information might help in the analyses of the overwater situation). Narrative discussion concerning ejectee reasons for both the actions taken and the sequence in which they were performed might help in assessing success or deficiencies in training programs and/or success or problems with equipments.

OPNAV 3752/10 (pages 1, 2 and 3 of 3) (Figs. 13, 14 and 15)

Section I. Conditions Prevailing at Survival/Rescue Site

This information can help in ascertaining causes for fatalities, injuries, delayed rescue, and other problems which, if clearly and correctly defined, might result in the future acquisition of improved systems and/or future development of improved techniques.

Section II. Time Lapse Sequence for Actual Rescue Vehicles/Personnel

Time lapse information is important in assessing the amount and types of survival equipments which should be provided ejectees as standard elements of the AAES (i.e., how long must an ejectee be essentially self-supporting relying only upon survival equipments provided with the system).

Section III. Time This Individual Spent

Hypothermia and poor flotation seem to be likely major causal factors/associated factors for many drownings and possibly some lost at sea ejectees. Time spent in water and in raft when combined with air temperature, water temperature and information concerning other conditions might help better define the post-ejection in-water survivors' problems.

Sections VI. Rescue Alerting Means, VII. Alerting Communications Problems, VIII. Delays in Departures of Rescue Vehicle(s), IX. Rescue Vehicle Problems Enroute, X. Problems in Locating Individual or Keeping Individual in Sight, and XI. Rescue Equipment Used

SAR problems can be, and have been, very critical to survival or death of an ejectee. Better definition of these problems could direct attention to better systems, techniques and training for SAR forces or perhaps impact future AAES technology in ways enhancing ejectee survival, detectability by rescue forces, and rescue.

Section XII. Survival Problems Encountered by This Person

This information helps in defining the degree of self-sufficiency required by an ejectee under various conditions for survival and suggests problems requiring resolution. Certain of these data will be analyzed with other information presented on the various pages of the completed FSR to better define the types, frequency and severity of survival problems.

Section XIII. Problems That Complicated Rescue Operations

This information will be analyzed in conjunction with that presented in Sections VI, VII, VIII, IX, X, and XI.

Section XIV. Individual's Physical Condition

This information can help define both survival and rescue problems and their causes and will be analyzed in conjunction with other information presented in the FSR to define system/equipment, training and other requirements.

OPNAV 3752/11 Analysis, Conclusions and Recommendations (Fig. 16)

This is probably one of the most important parts of a well prepared FSR and one of the most dangerous for poorly prepared, poorly reasoned ones. This section has been used to advance many novel ideas as well as time worn "classic" ideas. Caution should be exercised by the FSR preparer in developing and presenting analyses, conclusions and recommendations to ensure that they are supported by, and in consonance with, the facts reported throughout the FSR or that full explanation is provided for the discrepancies. The preparer needs to fully document and explain his analyses, conclusions and recommendations so that all who read them can understand the statements and the associated rationale, irrespective of their agreeing or disagreeing with them.

This section will be examined under the Data Program in the light of the collections of other cases to ascertain which analyses, conclusions and/or recommendations appear most likely to best define problems, requirements and/or solutions.

TYPICAL PLANNED ANALYSES AND THEIR FSR DATA NEEDS

At present the Aircrew Automated Escape System (AAES) In-service Usage Data Analysis Program is primarily directed toward development and implementation of automatic data analysis techniques capable of

providing rapid, repeatable, non-labor intensive (and therefore less error prone) analysis automatically as the data bank is updated. Staffing limitations coupled with recent personnel losses make exceedingly difficult simultaneously developing and implementing such techniques and performing specific analyses. Nonetheless, to a limited degree, the Data Program is proceeding with analyses of the available data. In many instances these, as well as future planned analyses, cannot be completed until the data bank is expanded to include data from ejections prior to 1969, perhaps back to approximately 1954, and upgraded to include data for ejections occurring after the initial transfer of data.

What are some typical on-going and planned ejection data analyses? What techniques and what data are being or will be used in these analyses? What problems must be overcome to develop meaningful analyses capable of generating what sorts of outputs to impact Fleet AAES/ALSS problems? Is the Data Program just an academic exercise or is it likely to serve a useful purpose in resolving Fleet AAES/ALSS problems?

One of the many problems subjected to preliminary analysis with plans for later in-depth analysis under this Data Program is that of the out-of-envelope ejectee. The most obvious question concerning this problem, a question that has generated considerable controversy and virtually no agreement is: Why did ejection occur out of the escape system's performance envelope? Preliminary analytic efforts concerning that question are presented as Figure 21 while preliminary thinking concerning the inseparable issue of why an ejection might be classified as having been initiated out-of-the-envelope is set forth in Figure 22. In addition, the preliminary review conducted on the data suggests that there well may be an interrelationship between many of the out-of-envelope ejections and many of the failures of aircrew to eject prior to aircraft impact with the surface.

In some cases determination whether an ejection was initiated within or outside an escape system's performance envelope is a very complex question requiring information concerning:

- o Aircraft parameters
  - airspeed
  - altitude above terrain and terrain profile
  - descent rate
  - attitude
  - rate of attitude change
  - accelerations during initiation and egress phases of escape

- o Escape system configuration
  - type escape system
  - location within aircraft
  - system stabilization effectiveness
  - system timing
  - trajectory control/alteration/divergency
  - parachute functioning
- o Total ejected weight
- o Total weight suspended under parachute
- o Type landing terrain
- o Ejectee physical condition from onset of emergency through rescue or death

as well as other data normally furnished in an FSR. Manipulation of these data requires generation and use of a number of formulations and standard data banks for each aircraft-escape system combination in service. Except when ejection is abruptly stopped by aircraft impact with the surface (a type 2 ejection) or the non-malfunctioning system sequencing is abruptly stopped by impact with the surface or surface objects, resolution of the in or out-of-envelope issue may be too complex for easy answers.

What must be done to reduce the incidence of out-of-envelope ejections and failures to eject? The preliminary data reviews completed were not sufficient to provide sufficiently clear and complete problem definitions suitable for initiating and guiding design efforts. However, they offer some initial insights into the problems and the general nature of possible solutions:

- o When the emergency is not an aircraft failure or a departure from controlled flight, resolution of both the out-of-envelope ejection and the failure-to-eject problems might not involve changes to the escape system but might involve development of means for avoiding unintended surface contact by the aircraft, possibly with emphasis on specific missions or phases of flight such as shallow dive angle bombing, strafing, night landings, or foul weather low level flights over rough terrain.

- o When the emergency involves aircraft failure or a departure from controlled flight occurring under conditions within the escape system performance envelope, resolution of both the out-of-envelope and failure-to-eject problems might involve improving means influencing aircrew escape initiation decisions to ensure a greater proportion are initiated well before the performance envelope margins are reached or breached.

- When the emergency involves aircraft failure or a departure from controlled flight occurring at or below minimum existing performance capabilities, resolution of the out-of-envelope ejection and failure-to-eject problems might require both enhancement of the escape envelope and the speed of aircrew decision to initiate escape.

Further analyses are required and planned to develop the data more completely to ascertain whether the preliminary indications are valid and, if so, to define the problems in ways that will aid designers in comprehending and addressing them.

Another problem, a perennial one, is the issue of ejecting through-the-canopy versus jettisoned-canopy, partially-cut-canopy or totally-fragmented-canopy ejection. Aspects of this problem are addressed in separate papers enclosed in this brochure. Similarly, flail, a long standing, ever present problem, is addressed in separate papers included in this brochure and therefore need not be treated in depth in this paper. However, both problems have been the subjects of considerable preliminary data review and analyses and, it is planned, will be the subjects of continuing efforts within the Data Program as the effort of achieving automated data analyses progresses.

A fourth example is one that also has long stood, that of helmet loss. Some preliminary data sorts have been made and some preliminary findings offered in October 1981 during a presentation at the Aircrew Automated Escape Systems (AAES) Data Analysis Program Symposium. Additional efforts are planned but are not expected to begin in the near term.

A major problem confronting the Data Program is the vast trove of ejection data already available and the many problems awaiting investigation. Some are now underway and many are planned but awaiting the availability of resources. Others are planned but are awaiting acquisition of additional data; for example the development, solicitation and analyses of questionnaires to amplify or clarify the existing data.

What is the role of the ejection investigator and/or FSR preparer in this effort? Figure 23 depicts the data chain which provides the data used by this Data Program while Figure 24 lists some of the expected use-oriented results of the analyses to be conducted. The ejection investigator and FSR preparer are extremely critical links in the AAES data chain, for it is they who provide the data used in the Data Program. Very little data not gathered and reported during the investigation and preparation of the FSR can be obtained by the Data Program. Hence, if the information is not acquired or, although acquired, not reported, it cannot be analyzed to help define problems. If data reported either is inaccurate or incorrect or is incorrectly entered into the FSR, that data might not be detected as being faulty and thus might adversely affect the analyses and problem definitions. One specific aspect of the MORs and now the FSRs has been, and is, especially vulnerable to these types of problems and, therefore, requires specific addressal: determining causes of injuries and/or problems.

ASCERTAINMENT AND REPORTAGE OF THE CAUSATION OF EJECTION ASSOCIATED INJURIES AND PROBLEMS

The ejection investigator often faces an extremely difficult task of explaining the causes of injuries incurred during ejections or of problems experienced during the escape. In many, if not most, cases the investigator is confronted either with major gaps in the available data (eg., ejectee cannot recall, no witnesses, equipment lost, etc.) or with apparent or actual contradictions (eg., disagreement between witnesses' reported observations, discrepancies between witnesses' observations and condition or location of equipment, etc.). How should the investigator resolve these problems, what actions should he take?

Probably the single most important task which the investigator is required to perform is the search for, and the accurate and complete reportage, of all facts concerning the ejection and identifying how each reported fact or piece of information was ascertained (eg., measured with a ruler, measured with 25 ft. tape, measured by pacing off the distance; reported by ejectee, reported by witness, reported by investigating team members; statement from a manual, statement from an expert, hypothesis; etc.). Probably the least useful and often most dangerous thing an ejection investigator can do is to guess concerning the causal factors of reported events, problems and injuries and/or to arbitrarily rule out reported facts and information without both explaining that such action has been taken and defining clearly the reasoning underlying that action.

One of the aspects of ejection investigation which at first appears helpful only to later turn out to cause more troubles than it helps to solve, is the existing extensive body of what might be termed "classical causal factors" for ejection associated injuries and/or problems. These are the "hand-me-downs" passed from one generation to the succeeding generation of ejection investigators. Most of us, be they engineers, flight surgeons, life support equipment officers, aviation medical safety officers, pilots, naval flight officers, etc., even aviation physiologists, have heard and perhaps without any question accepted some of these long-accepted, taught and used explanations for certain types of injuries and/or problems associated with ejection. These appear with frequency, unchallengeable articles of faith, in the FSRs (Flight Surgeon's Reports). Thus we see upon occasion in an FSR causal factors advanced that do not and cannot square with the facts reported for the individual case as, for example, in a recent ejection resulting in an upper arm fracture. After reporting that the ejectee's arms had flailed, the investigator stated that the cause for the fracture was windblast, even though the total airspeed of the aircraft at ejection reportedly was 3 knots. It is easy to understand the train of logic evolution in this case: the injury was a flail type break, flail classically is understood to be caused by windblast and, therefore, ipso facto, the break was caused by windblast.

Table I offers the reader a number of examples of common ejection related injuries and problems and the often cited "classical" causal factors. This list is offered not to provide a list from which causes may be selected (PLEASE DON'T) but, rather, as simply a list of what often are too pat answers to the question of why did that result occur.

What problems, however, if any, can use of classical causal factors or guessed causal factors induce? Such citations help to direct and constrain the definitions of problems and, in turn, focus the attention and efforts of those who attempt to correct the problems in very specific, often limited scope directions. The frequent result is that the fixes produced appear suitable since design, testing and evaluation are driven by the stated causal factors, although in actual service the problem continues to occur largely unabated after the fixes have been incorporated.

The Navy's resources are limited and those devoted to aircrew automated escape systems (AAES) and aircrew life support systems (ALSS) appear generally to be even more so. Thus the Navy cannot afford attempting solutions of incorrectly and/or misleadingly defined problems. Nor can the AAES/ALSS community afford the consequent ancillary result of appearing to either not care about aircrew problems or to not be sufficiently competent to resolve the "everyone knows about it" type problem that unresolved, long-existing problems soon become. And certainly, most importantly, our Navy aircrew deserve better from all of us.

There is another problem which, although serious, seldom, if ever, has impacted the ejection investigators but probably will soon. This problem does have serious impact upon the suppliers of Navy AAES/ALSS and, eventually, could have serious implications concerning AAES/ALSS cost, performance and availability. The problem is product liability. In many product liability cases excerpts of the investigations have been prepared by the Judge Advocate General's office for release and contain the classical and/or incorrect/misleading causal statements developed by the ejection investigator. (Another critical problem in this regard has been the appearnace in journals of articles describing ejection associated injuries and/or problems and offering as the determined causal factors some of the classical causal factors. In many instances the authors of such articles display to knowledgeable individuals a surprising degree of misinformed opinion and lack of knowledge concerning the equipments involved.) With respect to the product liability problem, an ejection investigator should keep in mind that increasingly the investigators are being called as witnesses and their statements as to the causal factors, influences and mechanisms then subjected to merciless public scrutiny. One should be prepared to very carefully and exactingly prove one's findings and theories, particularly if published in journals.

What on the other hand, is the problem if an ejection investigator cannot clearly identify certain causal factors and admits that fact. From the viewpoint of AAES/ALSS data analysis aimed at defining problems, lack of a defined causal factor does not pose any serious problems. Certainly not stating causal factors when one cannot be certain produces less of a problem than stating a not clearly proven causal factor. One should not, however, be discouraged from hypothesizing which might be the causal factor as long as one clearly indicates both that the factor listed as the causal agent is a hypothesis and the bases underlying that choice of agents.

In many instances the information obtained during a thorough investigation of a single ejection case (whether involving one or multiple individual ejectees) may be sufficient to permit identification of all injury and problem causal factors. However, in many cases, the information which the in-field investigator can develop is inadequate and assistance is needed. A considerable community of AAES/ALSS equipment expertise exists within the Navy, much of which can, on request, provide assistance. Table II lists and provides points of contact for U.S. Navy activities having specific and detailed expertise concerning AAES/ALSS. The investigator also should be aware that there exists an immense, growing body of data which, when properly treated and analyzed, might prove helpful in understanding or interpreting the data and information acquired for a specific case. (This latter aspect is discussed in more detail in a separate paper.)

To summarize, then, the critical points concerning the ejection investigator's task:

- o Identify and record all data
- o Where causation can be clearly established, so state and define bases for statement
- o Where hypotheses concerning causal factors seem reasonable, state them, identify them as hypotheses and furnish your rationale for the hypotheses.
- o Do not state event or causal factor guesses or hypotheses as though they were established.

NEED FOR NARRATIVE DESCRIPTIONS AND EXPLANATORY NOTES IN THE FSR

Throughout an ejection investigation and the subsequent preparation of the Flight Surgeon's Report (FSR), the investigator(s) and preparer(s) should remember that the FSR out of necessity is a checklist type

formatted report. The checklist format, of course, in part is used to simplify complicated tasks, such as ejection investigations, and to ensure completeness of reportage concerning common, anticipatable and/or potential aspects.

Throughout the FSR, therefore, checklist subsets are provided from which the preparer is required to select the term(s) or phrase(s) most applicable. These subsets are employed to solicit descriptions of events, problems and behavioral aspects frequently associated with or commonly occurring prior to, during and/or following an ejection. The terms and phrases offered usually are simple, often one, two or three words long, and can encompass a broad spectrum of specific aspects of an escape which share one or more common attributes.

Unfortunately, often, despite shared attributes, the lumping of specific aspects under one term conceals important differences among those for an individual case and among those for a collection of cases. Often concealed through lumping are those differences, such as relationship of a specific aspect with sequenced events (i.e., did "flailing - lower extremities" occur prior to, during or after man-seat separation, during drogue operation, during parachute opening shock, etc.), which would help clarify the actual causal mechanism(s). Thus lumping serves to make, for example, all "flailing - upper extremities" occurring after egress appear to be the same and, therefore, implicitly, likely to result from the same causal factors. In fact there are many likely causes, as for example, for "flailing - upper extremities" and, therefore, the oversimplified lumping may confuse those seeking to identify the causal mechanisms.

The complexity of specific aspects such as upper limb flail is discussed in greater detail in the accompanying paper entitled Preliminary Generalized Thoughts Concerning Ejection Flail Phenomena. It is because of the potential complexities hidden by the offered terms that throughout the FSR there are provisions for and requests for, narrative descriptions and/or explanations illuminating the specific aspect(s) covered by the selected term. In essence, then, when a report is fully annotated with explanatory notes, the terms have served as a checklist during the ejection investigation and FSR preparer, therefore, need to recognize the critical importance of the explanatory notes and to seek and report information which may help researchers and designers to identify and correct the individual causal mechanisms causing undesirable specific aspects. As examples of the degree of complexity which might be concealed, consider Figures 25 and 26 which are questionnaires currently being developed to enhance AAES community knowledge concerning upper limb flail and concerning post-egress tumble in the hopes that the underlying causes can thereby be identified and eliminated.

GUIDANCE AND ASSISTANCE FOR THE INVESTIGATOR/FSR PREPARER

As a side effort to the analytic effort being undertaken by the Naval Weapons Engineering Support Activity, an effort has been initiated with the assistance of the Naval Aeromedical Research Laboratories, Pensacola, to develop a number of field investigator guides concerning both the AAES and associated ALSS subjected to an emergency use. These guides are being developed in an attempt to aid the investigator/FSR preparer in conducting a thorough investigation to glean and report maximal information with a minimum of effort and confusion on their part and, also, to thereby enhance the quality and quantity of information presented in FSRs. Preliminary drafts of the guides for examining and investigating helmets and oxygen masks have been prepared and are included in this brochure. In addition, a very general decision tree has been developed in preliminary form and included.

It is intended that these and other guides, as they are developed, will be evaluated during post-test investigative efforts following ejection tests and then furnished to selected flight surgeons and aviation physiologists for further evaluation and comment. If the guides appear suitable, helpful and acceptable, ways will then be sought to formalize their development, updating and availability.

TABLE I

OFTEN CITED CLASSICAL CAUSAL FACTORS FOR

INJURY AND PROBLEMS ASSOCIATED

WITH EJECTION

INJURY/PROBLEM	CITED CLASSICAL CAUSAL FACTORS
o Vertebral compression facture.	- Poor body position. - Poor restraint. - Seat acceleration. - Seat slap. - Scoliosis - Anthropometry
o Aviator rising off seat and/or striking canopy during negative G flight conditions.	- Loose lapbelt. - Poor restraint. - Mis-sized torso harness used.
o Helmet lost during ejection.	- Windblast. - Loose/broken chin strap. - No nape strap. - Improper fit/fit pads. - Wind under visor - Helmet weight/c.g.
o Limb flail.	- Windblast.
o Neck injury.	- (If present Ballistic spreader gun parachute opener induced excessive opening shock. - Poor body position. - Windblast induced helmet aerodynamic lift.

TABLE II

SOURCES OF OUTSIDE ASSISTANCE

FOR THE ACCIDENT INVESTIGATING FLIGHT SURGEON

AND AVIATION PHYSIOLOGIST

ALSS/AAES EQUIPMENT TYPE	ADDRESS	TELEPHONE NUMBERS
o Total Escape System/ Life Support System	Superintendent Life Support Engineering Division Aircraft and Crew Systems Technology Directorate Naval Air Development Center (603) Warminster, Pennsylvania 18974	215-441-2503 Auto: 441-2503
	Technical Director Crew Systems Division Naval Air Systems Command (AIR-531A) Washington, D.C. 20361	202-692-7486/ 7548 Auto: 222-7486
o Parachutes	Head Parachute Engineering Div. Parachute Systems Dept. Naval Weapons Center (641) China Lake, California 93555	714-939-2943 Auto: 437-2943
oCartridges/Cartridge Actuated Devices/ Cartridge (Ballistic) Catapults	Director CAD Engineering Division CAD/PAD Department Naval Ordnance Station (512) Indian Head, Maryland 20640	301-743-4261/ 4876 Auto: 364-4261
o Rocket Motors/ Rocket Catapults	Director Aircrew Escape Propulsion Division CAD/PAD Dept. Naval Ordnance Station (515) Indian Head, Maryland 20640	301-743-4757/ 4369 Auto: 364-4757
o Maintenance & General Systems	Head Air Crew Systems Branch Systems Engineering Test Directorate Naval Air Test Center (SY-71) Patuxent River, Maryland 20670	301-863-4141/ 4673 Auto: 356-4141

o FSR Data/ Data Analyses	Head Aeromedical Division Naval Safety Center Naval Air Station Norfolk, Virginia 23511	804-444-2261 Auto: 690-2261
	Head Life Support Equipment Branch Aircraft Maintenance and Material Division Naval Safety Center Naval Air Station Norfolk, Virginia 23511	804-444-3949 Auto: 690-3949
o AAES/ALSS Data Analyses	Head Systems Evaluation Division Production Data Systems Dept. Naval Weapons Engineering Support Activity (ESA-31) Washington Navy Yard Washington, D.C. 20374	202-433-3621/ 3623 Auto: 288-3621

FLIGHT SURGEON'S REPORT
GENERAL INFORMATION AND NARRATIVE DATA
OPNAV 3752/3

REPORT SYMBOL
OPNAV 3752-1
PAGE 1 OF 1

**THIS IS PART OF A LIMITED USE NAVAL AIRCRAFT MISHAP INVESTIGATION REPORT.
LIMITED DISTRIBUTION AND SPECIAL HANDLING REQUIRED IN ACCORDANCE WITH OPNAVINST 3750.6.**

I. GENERAL INFORMATION

1. Reporting Custodian of Mishap Aircraft	2. Mishap Severity	3. Mishap Category: ☐ Flight Mishap ☐ Flight Related Mishap ☐ Aircraft Ground Mishap

4. Mishap Serial #	5. Date and Time (local) of Mishap	6. Model A/C	7. BUNO	8. No. of Occupants

9. Name: (last, first, middle initial of individual involved (Use additional sheets, if necessary)	10. Sex	11. Check pilot in control at time of mishap	12. Grade/Rate	13. Branch of Service	14. In-flight Duties	15. Injury Classification	16. Disposition code
A. Pilot in command (at time of mishap)							
B. Copilot/others							
C.							
D.							

17. Terrain Clearance	18. Cabin Altitude	19. Time at Cabin Altitude	20. Ambient Altitude	21. Time at Ambient Altitude
______ feet (AGL)	______ feet	____ hours ____ tenths	______ feet (MSL)	____ hours ____ tenths

22. Place in Formation (N/A if single aircraft) ☐ 1 — lead ☐ 2 — wing ☐ 3 — other (Explain) ______	23. Duration of Flight ____ hours ____ tenths	24. Airspeed at Time of Mishap

25. Cloud Conditions	26. Horizon
____ 0 — clear ____ 1 — overcast ____ 2 — undercast ____ 3 — in clouds ____ 4 — in & out of clouds ____ 5 — other (specify) ______	____ 1—distinct ____ 2—obscured 3—other (specify) ______ visibility ______

II. MODEL OF OTHER AIRCRAFT (IF INVOLVED)

1. Reporting Custodian of this Aircraft	2. Model A/C
3. BUNO	**4. No. of Occupants**

III. NARRATIVE ACCOUNT OF MISHAP (Continue on a separate sheet, if necessary)

SUBMITTED BY: NAME (Flight Surgeon) ______ SIGNATURE ______ DATE ______

INSTRUCTIONS FOR COMPLETION OF FORM OPNAV 3752/3: GENERAL INFORMATION AND NARRATIVE DATA

I. GENERAL INFORMATION:

1. See OPNAVINST 3750.6.
2. Mishap severity (from MIR A, B, or C)
3. Self explanatory
4. From MIR e.g., 1-81, 3-81, etc.
5. Self explanatory
6. Self explanatory
7. Self explanatory
8. Number of occupants in mishap aircraft.
9. - 11. Self explanatory. For number 10, state (M) for male, (F) for female.
12. Give grade or rate, if military, e.g., LT, CAPT, E-1, etc. If civilian or foreign national, indicate as (CIV) or (FN), respectively
13. USN, USNR-R, USMC, etc
14. Refers to duties during mishap flight, e.g., pilot, BN (do not use term NFO), aft observer, passenger, etc.
15. For proper classification, see Chapter 4 of OPNAVINST 3750.6.
16. Disposition Code
    - A Insufficient remains recovered for autopsy but sufficient for tissue and/or fluid specimen analysis.
    - B Death due to cause(s) other than injuries sustained.
    - C Death after 48 hours due to injuries sustained and autopsy *not* performed.
    - D Death after 48 hours due to injuries sustained and autopsy performed.
    - E Death within 48 hours due to injuries sustained and autopsy *not* performed.
    - F Death within 48 hours due to injuries sustained and autopsy performed (include instantaneous and DOA)
    - G Hospitalization, observation, SIQ, or grounding exceeding 48 hours.
    - H Returned to full duty between 12 and 48 hours after mishap, to include hospitalization, SIQ, and/or observation up to 48 hours
    - N Return to full duty between 0-12 hours after mishap.
    - U Disposition unknown. Includes remains lost or individual missing. Submit supplementary report if status changes

Questions 17-26 refer to the parameters at the moment the adverse occurrences began. If estimated, indicate by "est", if unknown, by "unk"

17. Distance above ground.
18. This varies between pressurized and nonpressurized aircraft. If unpressurized, it will be the same as the ambient altitude (no. 20). If pressurized, ask the survivor to what altitude the cabin was pressurized, or estimate same (est).
19. The amount of continuous time that the aircraft spent at that altitude. On a long cross-country, it will probably be close to the duration of flight (item 23). If during ACM or bombing run, it may be a very short period of time.
20. What the altimeter reads - the height above mean sea level.
21. Same as item 19, unless there has been a depressurization or change in cockpit pressurization during the flight at that altitude.
22. Self-explanatory.
23. From takeoff until mishap.
24. Ask survivor. If estimated, add ("est").
25. & 26. Self-explanatory. Visibility is given in statute miles.

II. MODEL OF OTHER A/C (IF INVOLVED):

If there were no injuries, fatalities, psychophysiological factors, escape/egress, or survival/rescue episodes involved and this aircraft was not a cause factor in the mishap, the information requested is all that is required. If this is not the case, an additional 3752/3 form for this aircraft is required. Instructions are the same as for Section I.

III. NARRATIVE ACCOUNT OF MISHAP:

Give a synopsis of the significant events leading up to, during, and following the mishap in the Flight Surgeon's own words. Emphasis should be placed on human factors, aeromedical, egress, survival, and rescue aspects of the mishap. The thrust of this narrative should only be "what" happened. "Why" and "how" belong in the analysis section of the OPNAV 3752/11 form. Do not include survivor or witnesses' statements in this section.

DO NOT WRITE HERE

FLIGHT SURGEON'S REPORT
MEDICAL INFORMATION
OPNAV 3752/4

REPORT SYMBOL
OPNAV 3752-1

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LIMITED DISTRIBUTION AND SPECIAL HANDLING REQUIRED IN ACCORDANCE WITH OPNAVINST 3750.6.

I. GENERAL

1. ____________ On Flight Status
2. ____________ Injury Classification
3. ____________ Days in Hospital
4. ____________ Days in Quarters
5. ____________ Days Limited Duty
6. ____________ Days Grounded
7. ____________ Duration of Altered State of Consciousness

II. INJURIES INCURRED DURING MISHAP (list additional injuries in IX)

			ICD Code	INJURY SEVERITY CODE
1.	Body Part			
	Diagnosis			
	Cause			
2.	Body Part			
	Diagnosis			
	Cause			
3.	Body Part			
	Diagnosis			
	Cause			
4.	Body Part			
	Diagnosis			
	Cause			
5.	Body Part			
	Diagnosis			
	Cause			

III. LAB TESTS

	Date Drawn (D-M-Y)	Elapsed Time	Lab Used	Tissue Used	Results	Lab Norm Range	Significant Factor
Carbon Monoxide							
Alcohol							
Brain Lactic Acid (Fatal)							
Drug Screen							
Hgb/Hct							
Other							
Other							

URINALYSIS: SP. GR. ________ SUGAR ________ KETONES ________ OTHER ABNORMALITIES ________

DATE TAKEN ________ ELAPSED TIME TAKEN AFTER MISHAP ________

IV. X-RAY RESULTS

☐ Check if performed. Where performed: ________

(Submit results on a separate sheet)

V. PRE-EXISTING DISEASES/DEFECTS AND DISEASES/DEFECTS PRESENT AT THE TIME OF THE MISHAP

Diagnosis	Method of Discovery				Waivers (as applicable)	
	Annual Physical	Sick Call	Autopsy	Other	Authority	Date

VI. SMOKER ☐ Yes ☐ No # packs/day ________ Has smoked for ________ years.

VII. AUTOPSY

1. Conducted By/In Progress By:
________ M – Military Pathologist ________ F – Flight Surgeon
________ C – Civilian Pathologist ________ Y – Other

2. Material Submitted to AFIP:
________ 1 – Autopsy Report ________ 3 – Pictures
________ 2 – Frozen Tissue ________ 4 – Fixed Tissue

3. ☐ Protocol Attached ☐ Not Yet Forwarded

NAME OF THIS INDIVIDUAL ________ SSN ________ AIRCRAFT ________ BUNO ________

INSTRUCTIONS FOR COMPLETION OF OPNAV 3752/4: MEDICAL INFORMATION

I. GENERAL:

1 Flight Status: Check if on competent flight orders regardless of actual participation in mishap. Otherwise leave blank.
2 - Injury classification in accordance with Chapter 4 of OPNAVINST 3750.6.
3 - Self-explanatory.
4 – Include days spent as "sick-in-quarters" or on convalescent leave. Used as an indication of time not available for any duty.
5 – Excludes hospitalization, convalescent leave, and S.I.Q.
6 – Include total days grounded including day of mishap but not day of return to flight status. Do not include days hospitalized and/or S.I.Q. and/or on convalescent leave.
7 – Altered state of consciousness as defined in International Classification of Disease (ICD) 780. Duration in hours and minutes.

II. INJURIES INCURRED DURING MISHAP:

List injuries in decreasing order of severity. In fatal cases, list primary cause of death first. Use standard medical terminology for body parts and diagnosis, and insert ICD code which most nearly describes injury in column provided. Indicate the estimated injury severity of each injury as if no other injury were present, using OPNAVINST 3750.6. For "Cause," briefly describe the mechanism of injury, i.e., "Hyperflexion," "Blunt Trauma," etc. (Explain in detail on the 3752/11 form.) Indicate external factors which affected mechanism of injury only if those factors can be established with a reasonable degree of confidence, and describe means for establishing that confidence, i.e., "paint from seat found on helmet," "aircrew statement," "rescuer's statement," etc. on the 3752/11 form. In the event more than five injuries were sustained, list the remaining injuries in Section IX. List all injuries (little things are important). Do not simply state "injuries multiple extreme" for fatalities.

Example:

			ICD Code	INJURY SEVERITY CODE
1.	Body Part	Lumbar spine L-3	805.2	D
	Diagnosis	Anterior compression Fx		
	Cause	Hyperflexion due to ejection forces		
2.	Body Part			
	Diagnosis			

III. LAB TESTS:

Retain aliquot of frozen blood and urine for future use/verification, as per OPNAVINST 3750.6. Brain lactic acid to be obtained on all fatalities. Both serum and urine shall be submitted for drug screen testing.

"Elapsed Time" – indicate time in hours and minutes from time of mishap to time specimen obtained.

For all abnormal lab values, provide an explanation for value or indicate plan for follow-up studies. Results of follow-up studies shall be forwarded to the Naval Safety Center (Code 14). State whether abnormal lab results were significant or not to mishap. Place any additional lab results in Remarks section.

IV. X-RAY RESULTS:

Spinal x-rays are required following all ejections/bailouts or in any instance of suspected back injury as evidenced by pain or limitation of motion. Attach copy of x-ray reports to this form. Indicate name of facility where x-rays were made.

V. PREEXISTING DISEASES/DEFECTS:

List all known preexisting diseases/defects and diseases/defects present at time of mishap. Include all defects listed in BLOCK 74 of S.F. 88, such as defects of vision, hearing, etc.

VI. SELF-EXPLANATORY

VII. AUTOPSY:

Check as many boxes as are applicable.
Do NOT delay submission of FSR while awaiting return of AUTOPSY REPORT.

DO NOT WRITE HERE

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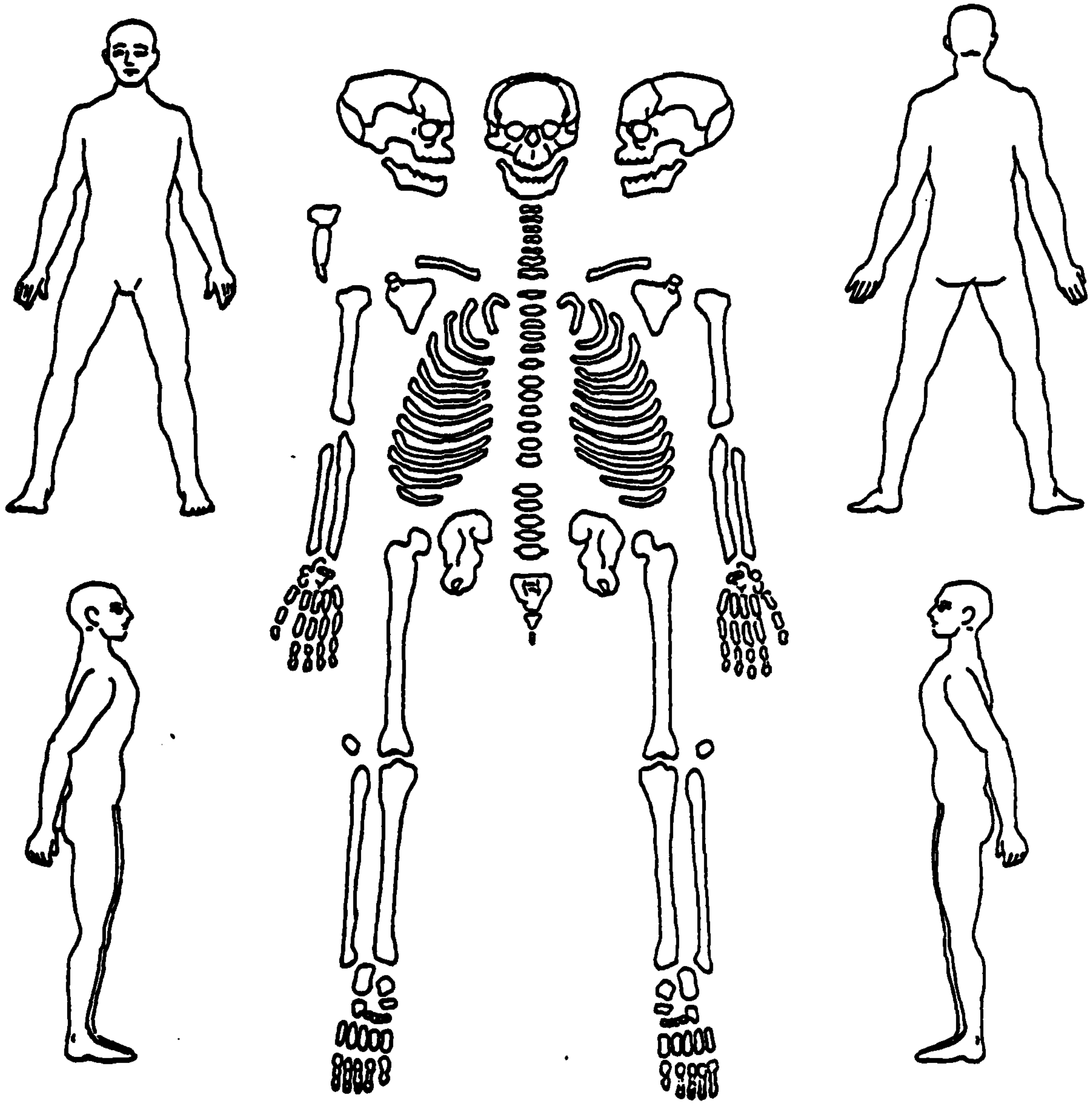
VIII INJURY PROFILE

(Please mark or draw injuries, where applicable)



IX REMARKS: List additional injuries and/or abnormal lab values related to this mishap, and any other pertinent remarks. (Continue on separate sheet, if necessary.)

NAME OF THE INDIVIDUAL ______________ SSN ____________ AIRCRAFT __________ BUNO __________

INSTRUCTIONS FOR COMPLETION OF OPNAV 3752/4: INJURY PROFILE

VIII. INJURY PROFILE:

Supplement with photographs where possible. Attach additional sheets of paper, as required. Send photos *only* to Naval Safety Center.

From external examination, specify exact location of the injury, abrasion, amputation, burn and degree, contusion, discoloration, hemorrhage, etc. on the included diagram.

From skeletal examination, specify exact location and type of fracture or dislocation on included diagram.

IX. REMARKS:

May be used for listing additional injuries, laboratory values, or any other information considered germane to investigation.

DO NOT WRITE HERE

FLIGHT SURGEON'S REPORT
PSYCHOPHYSIOLOGICAL AND ENVIRONMENTAL FACTORS
OPNAV 3752/5

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PLACE APPROPRIATE MISHAP FACTOR IMPORTANCE CODE (0=Present but did not contribute; 1=Possibly a factor; 2=Probably a factor; 3=Definitely a factor) in the applicable phase of mishap block (M=Mishap; E=Escape; S=Survival (includes parachute landings) and R=Rescue)

M E S R

1. SUPERVISORY FACTORS

A. Inadequate Brief/Checkout
B. Ordered/Led on Flight Beyond Capability
C. Failure to Allow for Adequate Rest
D. Tempo of Operations
E. Lack of Aircrew Surveillance
F. NATOPS Manual Inadequacy
G. Other

2. EXPERIENCE/TRAINING FACTORS

A. Limited Experience
B. Inadequate Transition
C. Lack of Currency/Proficiency
D. Inadequate Knowledge of A/C Systems
E. Inadequate Knowledge of ALSS
F. Other

3. HUMAN ENGINEERING DESIGN FACTORS

A. Design/Location of Instruments, Controls
B. Lighting
C. Workspace Incompatibility
D. Anthropometric Incompatibility
E. Confusion of Controls, Switches, Etc.
F. Misread Instruments
G. Visual Restrictions Due to Structure
H. Task Oversaturation
I. Inadvertent Operation
J. Cockpit Standardization (Lack of)
K. Personal Equipment Interference
L. Inadequate Crashworthy Design
M. Other

4. COMMUNICATIONS FACTORS

A. Misinterpretation
B. Noise Interference
C. Disrupted Communications
D. Poor Crew Coordination
E. Other

5. ENVIRONMENTAL FACTORS

A. Acceleration/Deceleration Forces
B. Decompression
C. Vibration
D. [illegible]
E. Windblast
F. [illegible]
G. [illegible]
H. Smoke, Fumes in Cockpit
I. Air Turbulence
J. [illegible]
K. [illegible]
L. Toxic Chemicals
M. Work Area Lighting
N. Radiation
O. Pitching Deck
P. High Seas
Q. Electrical Shock
R. Noise
S. Other

6. MEDICAL FACTORS

A. Poor Physical Conditioning
B. Motion Sickness
C. Fatigue
D. Sleep Deprivation
E. Missed Meals
F. Medication(s) (self-prescribed)
G. Medication(s) (MD-prescribed)
H. Altered Consciousness
I. Disorientation, Vertigo
J. Visual Illusions
K. Hypoxia
L. Hyperventilation
M. Dysbarism
N. Circadian Rhythm Disturbance
O. Hypothermia
P. Hyperthermia
Q. Other Acute Illness(es)
R. Pre-Existing Disease(s)
S. Other

7. BEHAVIORAL FACTORS

A. Faulty Planning (Pre-Flight, Flight)
B. Haste (Hurried Departure, etc.)
C. Get-Home-Itis
D. Boredom, Inattention, Distraction
E. Preoccupation with Personal Problems
F. Overconfidence, Excessive Motivation
G. Lack of Confidence
H. Apprehension/Panic
I. Violation of Flight Discipline
J. Error in Judgment
K. Delay
L. Lack of Motivation
M. Interpersonal Tensions
N. Inadequate Stress Coping
O. Drug Abuse
P. Alcohol/Hangover
Q. Other

NARRATIVE: [illegible] explain. Use separate sheet, if necessary.)

[illegible] ________ SSN ________ AIRCRAFT ________ BUNO ________

INSTRUCTIONS FOR COMPLETION OPNAV 3752/5: PSYCHOPHYSIOLOGICAL AND ENVIRONMENTAL FACTORS

PARAMETERS:

For appropriate factor importance codes, see form. Care and sound judgment based on all facts shall be exercised in the selection of items in this section. A brief explanation concerning each item selected shall be made in the "remarks" section. A complete and full discussion of each factor selected shall appear on the Flight Surgeon's Analysis, Conclusions, and Recommendations form (3752/11).

DEFINITION OF TERMS:

M or Mishap phase: From the beginning of the emergency until its termination, with the occupant still inside the aircraft or until this occupant initiated an attempt to escape from the aircraft.

E or Egress/Escape phase: From the initiation of the escape procedure until actual exit from aircraft (on ground), or until contact with the ground or water (after inflight escape).

S or Survival phase: From the completion of ground/water egress or parachute landing until physical contact was established with rescue personnel or rescue vehicle.

R or Rescue/Recovery phase: From the time rescue personnel actually reached the individual until he has been recovered aboard ship or hospital, or until rescue attempts were abandoned.

1. "Supervisory Factors" shall be applicable to any and all levels of supervision, as appropriate, from petty officer to the highest levels of command.
2. Experience/Training Factors:
   E. "ALSS" – Aviation Life Support Systems include ejection system (seat, parachute, restraint systems, etc.), O_2-mask, flotation equipment, signaling devices, etc.
3. Human Engineering Design Factors:
   B. "Lighting" includes the design of cockpit lighting, formation lights, runway/carrier landing platform lighting, etc. which affects aircrew performance (does not include lighting of maintenance workspaces, etc.).
   L. "Inadequate Crashworthy Design" includes the design of such items as the airframe, aircrew restraints, fuel systems, etc.
4. Communications Factors:
   A. "Misinterpretation" includes difficulty in understanding foreign accents or language, unintelligible utterings, nonstandard nomenclature, etc.
5. Environmental Factors:
   A. "Acceleration Deceleration Forces" applies to any phase of the mishap wherein these forces act as an adverse factor but does *not* include cases where death resulted from extreme deceleration forces or the complete disintegration of the aircraft on impact.
   M. "Work Area Lighting" refers to such things as inadequate lighting of maintenance spaces, line areas, or any problem with low lighting levels of workspaces.
6. Medical Factors:
   A. "Poor Physical Conditioning" includes any significant obesity.
   H. "Altered Consciousness" includes the full range from dazed to complete loss of consciousness, according to the International Classification of Disease Code 780.
7. Behavioral Factors:
   M. "Interpersonal Tensions" refers to problems relating to others, e.g., wife, peers, superiors, subordinates.
   N. "Inadequate Stress Coping" refers to a problem in any phase which might affect the aircrewmember because of his inability to handle that level of psychological stress, whether it be due to an inflight emergency or to cumulative life difficulties/stresses.

DO NOT WRITE HERE

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LIMITED DISTRIBUTION AND SPECIAL HANDLING REQUIRED IN ACCORDANCE WITH OPNAVINST 3750.6.

I. AVIATION PHYSIOLOGY, EGRESS, AND WATER SURVIVAL TRAINING DATA:

A. Did the training contribute to any injury, rescue, or survival problem? YES ☐ NO ☐ POSSIBLY ☐

B. Did the lack of training contribute to any injury, rescue, or survival problem? YES ☐ NO ☐ POSSIBLY ☐

NOTE: If the answer to either A or B is yes, please explain on form 3752/11.

C. Type Syllabus (most recent). Check one: TAC JET_____ HELO_____ CARGO/TRANS._____ OTHER _____

D. List only the most recent training	Place Training Accomplished	Completed (month, year)	Role in Mishap*
Naval Aviation Physiology Training Program (NAPTP)			
1. Physiology Lectures			
2. Chamber flight (type profile)			
3. Sensory Visual Problems			
4. Sensory Flash Blindness			
5. Sensory Scan Training			
6. Spatial Orientation-Lecture-Portovon			
7. Spatial Orientation-Vertigon (SMU-97/F)			
8. Spatial Orientation-MSDD (986)			
9. ALSS Lecture			
10. ALSS "hands on" training			
11. Signalling Devices (Drills)			
12. Emergency Egress System Lecture			
13. Emergency Ground Egress			
14. Emergency Bailout Egress			
15. Ejection Initiation (seat shot)			
16. Seat-Man Separation Drill			
17. Parachuting (four-line release)			
18. Seat Kit Deployment/Use Drill			
19. Emergency First Aid			
20. Helo Rescue (Land Phase) 9H1			
21. Annual Ejection Seat Training			
Naval Aviation Water Survival Training Program (NAWSTP)			
22. Water Survival Training-Lectures			
23. Water Survival Training-Drills			
24. Deep Water Environment (DWEST)			
25. Parasail Training			
26. Parachute Drag Training 9F2/9F2A			
27. Parachute Disentanglement 9F6			
28. Underwater Breathing 9H19			
29. Dilbert Dunker 9U44 series			
30. Multi-placed Dunker 9D5 series			
31. Helo Rescue (Water Phase) 9H1			
OTHER TRAINING			
32. Cold Weather Environmental Survival (CWEST)			
33. Jungle Environmental Survival (JEST)			
34. Desert Environmental Survival (DEST)			
35. Survival, Evasion, Resistance, Escape (SERE)			
36. Other			

*For role in mishap, use following codes:

1. Definitely helped
2. Possibly helped
3. Lack of training a possible factor
4. Lack of training a definite factor
5. Possibly hindered
6. Definitely hindered
9. Unknown
0. Not a factor

II. BACKGROUND: (complete for all pilots and for others who possibly contributed to mishap)

A. Leave Data

1. Date last leave taken _____
2. Duration last leave (days) _____
3. Type of leave last taken

_____ 1. Ordinary _____ 3. Sick or Convalescent

_____ 2. Emergency _____ 9. Unknown

B. Flight Data

1. Date of last flight: _____

NAME OF THIS INDIVIDUAL _____ **SSN** _____ **AIRCRAFT** _____ **BUNO** _____

INSTRUCTIONS FOR COMPLETION OF OPNAV 3752/6: PERSONAL DATA

I. TRAINING:

All training requirements must be in accordance with OPNAVINST 3710.7 series and type commander directives. Answer items A and B by checking correct space. *Fully explain* a "yes" or "possibly" answer in the Analysis section (OPNAV 3752/11)

This information can be obtained from the health record/individual NATOPS training jacket, or from the site where the training was conducted. If training is *deficient*, e.g., out-of-date, a comment is required on the 3752/11 form. Item D36 refers to any other schools and/or training programs that this individual may have attended. Squadron training and any "other" physiology, egress and/or water survival training programs should also be listed. A copy of the training record from the health record or NATOPS qualification jacket should be included.

NOTE. Section I may be omitted on "selected" passengers that were not required to have the training. (A statement of this fact is required.)

Terms "A L S S" Aviation Life Support Systems

DO NOT WRITE HERE

C. Work/Rest Data:

1. Hours worked:
   a. in last 24 hours: ______ hours
   b. in last 48 hours: ______ hours
   c. in last 72 hours: ______ hours
2. Continuous duty prior to mishap: ______ hours
3. Time in cockpit prior to flight (in hours and tenths): ______ hours
4. Hours continuously awake prior to mishap: ______ hours
5. Hours slept:
   a. in last 24 hours: ______ hours
   b. in last 48 hours: ______ hours
   c. in last 72 hours: ______ hours
6. Duration of last sleep period: ______ hours
7. Last sleep period was (see instructions)
   a. continuous ______ b. broken ______

III ANTHROPOMETRIC DATA:

A. Height: Inches ______

B. Current Weight: Pounds ______

C. Sitting Height: Inches ______

D. Trunk Height: Inches ______

E. Functional Reach: Inches ______

F. Buttock-Knee Length: Inches ______

G. Buttock-Leg Length: Inches ______

H. Shoulder Width (Bideltoid): Inches ______

I. Anthropometric Coding (4 digit code IAW NAVAIRINST 3710.9) ______

J. Other: BUTTOCK - POPLITEAL

IV GENERAL:

A. Date of Birth ______ Day ______ Month ______ Year

B. Date of last flight physical ______

C. Total years of formal education ______

D. Highest degree attained ______

E. Number and type of prior mishaps (complete for all pilots and/or other persons in control of aircraft).
   1. Number ______ 2. Type aircraft ______
   3. Describe mishap(s) briefly: ______

V. CHRONOLOGICAL ACCOUNT OF ACTIVITIES OF PREVIOUS 72 HOURS

(For all pilots, co-pilots, and/or persons possibly contributing to mishap. Continue on separate sheet, if necessary.)

NAME OF THIS INDIVIDUAL ______ SSN ______ AIRCRAFT ______ BUNO ______

INSTRUCTIONS FOR COMPLETION OF OPNAV 3752/6: PERSONAL DATA

II. BACKGROUND:

C.7."Sleep period" refers to a normal regular prolonged sleep period. An example of a "broken" sleep period is: An aircrewmember has the SDO watch, sleeps from 2200 to 0600, but is awakened three times by phone calls.

III. ANTHROPOMETRIC DATA:

Complete items A through H on all aircrewmen. Complete items A through I on all pilots and NFOs. Also complete A through I on any other individual who ejected, bailed out, or experienced any difficulty with equipment, fit, or egress. *Complete item I IAW NAVAIRINST 3710.9.* List as "other" in block J any unlisted measurements which result in anthropometric problems.

IV. GENERAL:

Items A, B, and D self-explanatory. Item C includes 12 years of education through high school, 4 years of college training, and any years spent in graduate education. Items E(1) and E(2) include all prior aircraft mishaps regardless of the cause of the mishap. This information shall be obtained from the NATOPS *Flight Training Qualifications* Jacket. Describe the circumstances of the mishap(s) and include any pertinent facts concerning the mishap in Item E(3).

V. CHRONOLOGICAL ACCOUNT OF ACTIVITIES OF PREVIOUS 72 HOURS:

This history should begin 72 hours prior to the time of the mishap and proceed in a chronological order. Among important items to consider are: (1) exact content of meals (if known), (2) alcohol consumption, (3) sleep periods, (4) stressful situations of any nature, (5) significant events, and (6) medications/drugs. Items listed should be accompanied by time of occurrence (if known). Provide comments concerning any deviation from normal habit patterns. An example is provided:

CHRONOLOGICAL ACCOUNT OF ACTIVITIES OF PREVIOUS 72 HOURS (sample):

FRIDAY: 2 OCT 81

1800 Ate dinner at home: turkey, mashed potatoes and gravy, peas, 2 glasses of red wine, coffee and apple pie a la mode.
1900 Relaxed with family, watched TV, ate popcorn, drank 1 glass sherry.
2300 Went to bed. Took 2 *Coricidin* tablets for residual URI.

SATURDAY: 3 OCT 81

0700 Woke up, ran 2 miles.
0800 Showered, breakfast with family: 1 egg, 2 strips bacon, 1 slice toast, orange juice and coffee.
0830 Read paper, relaxed.
0900 Worked on car, mashed finger, finger throbbing, took 2 APCs, treated finger with iodine, band-aid.
0930 Cut grass.
1130 Ate lunch: bologna sandwich, iced tea.
1200 Went shopping with wife.
1700 Dinner at a pizza parlor – ate half of a large pepperoni and mushroom pizza, drank small pitcher of beer.
1800 Went to movie with family.
2030 Arrived back home, relaxed, listened to music, 1 glass brandy.
2200 Went to bed.
2300 Finger throbbing, got up and took 2 APCs.
2330 Back to bed.

SUNDAY: 4 OCT 81

0800 Woke up, ran 2 miles.
0900 Showered, breakfast with family, 8-ounce glass orange juice, coffee, 2 waffles with syrup.
0930 Read Sunday paper.
1030 Dressed for church.
1100 Left to go to church with family.
1330 Lunch at hamburger joint, 1 quarter-pound cheeseburger, fries, and large coke.
1400 Took kids to zoo and park.
1600 Returned home, watched sports on TV, 2 beers.
1900 Supper at home, spaghetti and meat sauce, 2 glasses Chianti, salad, 2 slices garlic bread.
2000 Call from mother: father had heart attack, in hospital, condition – satisfactory.
2200 1 glass sherry, went to bed.
2300 Awakened by baby crying, helped wife with sick baby.
2400 To sleep.

MONDAY: 5 OCT 81

0530 Awoke, ran 2 miles.
0600 Showered, dressed for work, no breakfast.
0630 Left for squadron.
0700 Arrived at squadron.
0730 Brief for flight.
0900 Fly – one-on-one ACM mission with F-14s from sister squadron.
1015 Land at NAS Homebase.
1040 Debrief.
1100 To Division Office, paperwork.
1200 Lunch: hot dog, coke, candy bar.
1300 In Squadron maintenance spaces.
1630 Brief for hop.
1700 T.O.
1800 Firewarning light, observed deteriorating engine instruments, flames and smoke, ejected – no injury.
1815 Rescued by SAR helo.
1830 Landed at NAS Homebase, to dispensary.

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NOMENCLATURE	Specific Type	Required	Available	Used/Worn	Needed	PROBLEM(S)/ CONDITION(S) CODE
1. HELMET						
a. Helmet Visor						
b. Chin Strap						
c. Nape Strap						
d. Reflective Tape						
2. GLASSES (prescription/plano)						
3. OXYGEN MASK						
a. Oxygen Regulator						
b. Oxygen Mask Retainer Fittings						
4. UNDERWEAR						
5. FLIGHT SUIT						
6. FLIGHT GLOVES						
7. BOOTS						
8. ANTIEXPOSURE SUIT						
9. SURVIVAL VEST						
CONTENTS:						
a. Radio						
b.						
c.						
d.						
e.						
f.						
g.						
h.						
i.						
j.						
10. HARNESS, INTEGRATED RESTRAINT, MA-2(SIZE)						
11. HARNESS, NONINTEGRATED STANDARD						
12. HARNESS, OTHER						
13. HARNESS, INTEGRATED RESTRAINT (MA-2) MODIFIED BY ACC-380 (size)						
CONTENTS:						
a.						
b.						
c.						
d.						
e.						
f.						
g.						
h.						
i.						
14. ANTI-G-SUIT						
15. LIFE PRESERVER						
Autoinflator						
16. LIFE RAFT						
17. EJECTION SEAT						
a. Restraint System						
b. Leg Restraint/Garters						
18. PARACHUTE						
a. Parachute Canopy Release						
b. Automatic Parachute Divestment Devices						
c. 4-line release						

NAME OF THE INDIVIDUAL ______ SSN ______ AIRCRAFT ______ BUNO ______

INSTRUCTIONS FOR COMPLETION OF OPNAV 3752/7: AVIATION LIFE SUPPORT SYSTEMS

List all individual protective equipment and life support systems (e.g. O_2 regulator, multiplace liferaft, parachute) that did or could have affected survivability. For numbers 9, 13, 19, and 20, continue listing in number 22 or on separate sheet, if necessary.

In the column "specific type," list the specific model of equipment/clothing, when applicable, in accordance with NAVAIR 13-1-6 series Crew Systems Manuals maintained by the life support equipment specialist. For ejections, the specific type and model of ejection seat and type of parachute shall always be listed (i.e., don't just say Martin-Baker, Escapac, etc.). Consult with life support equipment and ejection seat personnel to ensure that specific nomenclature and types of equipment are properly listed. Include service changes and modifications to aid in pinpointing the identity and configuration of a particular item. The part number is useful and should be included when possible.

When applicable, the columns "required," "available," "used/worn," and "needed" are to be filled in with a "Y" for yes, "N" for no, or "U" for unknown. The column "required" refers to items that were required by "official directives." For example, OPNAVINST 3710.7, NAVAIR 13-1-6 series manuals and/or type commander directives. (Note: If other than OPNAVINST 3710.7, or NAVAIR 13-1-6 series, list the directive). "Available" indicates that the individual had this with him or available to him at the time of the mishap. "Used/Worn" is self-explanatory. "Needed" indicates that the item did or could have improved survivability.

The column "problem(s)/condition(s)" is extremely important and shall be completed with a great deal of care. Enter the codes only if the problem/ condition is known/reported or real evidence exists to substantiate it. The fit of flight clothing/garments (e.g., torso harness, helmet, anti-G suit) shall be specifically addressed in terms of its effect(s) on performance and survivability. All problems/conditions coded shall be discussed in the Remarks section.

Use specific code number(s) to indicate the nature of a problem/condition whenever possible. For example, in the case of a failure, in addition to or instead of entering a 10, any of the following could also be applicable: 15, 17, 21, 35, and/or 36. More than one problem/ condition may apply and any one problem/condition frequently leads to another. Ensure the codes are listed in chronological order of occurrence. Add the phase of the mishap (see mishap phase codes) to the number, when known. Bracket all related problems/conditions. Example: A pilot loses his helmet during ejection because the chin strap is not tightened properly. During helo rescue hoisting, he hits his head on the helo and suffers a scalp laceration and concussion. In the "problems" column, enter the following on the line where helmet data have been reported (24M, 04E, 45R). Bracket the items to indicate relationship of events.

The "Problem/Condition" codes provided represent most of the problem factors which historically have been associated with Life Support Systems. Ongoing studies of tabulations of these problems/conditions result in recommendations for the evaluation and development of improved ALSS, and in instructions for their maintenance and use to ensure maximum aircrew protection. Note: Do not list equipment as being damaged or failing if impact forces were of such magnitude that it could not have been expected to remain intact.

PROBLEM/CONDITION CODES

01 – Not available – supply problem
02 – Not available – left behind
03 – Discarded
04 – Lost
05 – Damaged – Minor
06 – Damaged – Major
07 – Burned – Minor
08 – Burned – Major
09 – Destroyed by extreme force/fire
10 – Failed to operate (radio, actuator, etc.)
11 – Operated partially
12 – Difficulty locating
13 – Beyond reach
14 – Connection/closure difficulty
15 – Connection/closure failure
16 – Release/disconnect difficulty
17 – Release/disconnect failure
18 – Inadvertent release/disconnect
19 – Inadvertent actuation
20 – Actuation difficulty
21 – Actuation failure
22 – Actuated by other person
23 – Restraint/attachment inadequacy
24 – Restraints/attachments not used properly for maximum protection
25 – Improper use (other)
26 – Unfamiliar with use
27 – Cold hampered use
28 – Injury hampered use
29 – Water hampered use
30 – Other equipment interfered
31 – Donning/removal problem
32 – Discomfort/bulkiness
33 – Poor fit
34 – Leaked
35 – Material deficiency
36 – Design deficiency
37 – Hangup/entanglement with A/C or other equipment
38 – Entanglement (Parachute suspension lines only) – Major
39 – Entanglement (Parachute suspension lines only) – Minor
40 – Dragging (Parachute only)
41 – Non-standard configuration
42 – Aided in location/rescue
43 – Not effective in location/rescue (used in area of SAR vehicles)
44 – Prevented/minimized injury
45 – Equipment problem (loss, failure, etc.) a factor in producing injury
46 – Equipment produced injury (hit by ejection seat, etc.)
47 – Failure/delay in using compromised survival/rescue
48 – All crew equipment (code only once)
49 – Maintenance/installation error
50 – Problem experienced by others in actuation/release of equipment
51 – Equipment damage – self-induced
52 – Equipment failure – self-induced
53 – Air dropped equipment
54 – Not available – needed
55 – Available – needed, not used
56 – Dislodged from normal position
60 – Other (specify)

MISHAP PHASE CODES

M = Mishap
E = Egress
D = Descent (after ejection/bailout)
L = Landing (parachute) from first contact with ground, water, building, tree, etc., until stable.
S = Survival
R = Rescue
U = Unknown
T = Not applicable

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NOMENCLATURE	Specific Type	Required	Available	Used/Worn	Needed	PROBLEM(S)/ CONDITION(S) CODE
19. SEAT SURVIVAL KIT CONTAINER ____						
CONTENTS: a. ____						
b. ____						
c. ____						
d. ____						
e. ____						
f. ____						
g. ____						
h. ____						
i. ____						
j. ____						
k. ____						
20. OTHER LIFE SUPPORT EQUIPMENT (Use also for ground personnel involved)						
a. ____						
b. ____						
c. ____						
d. ____						
21. ID TAGS ____						

(APPROPRIATE REFERENCE FOR THIS SECTION: NAVAIR 13-1-6 SERIES MANUAL. AVAILABLE AT PARALOFT)

22. REMARKS: List number and letter of each problem/condition marked above and briefly explain.

NAME OF THIS INDIVIDUAL ____________ SSN ____________ AIRCRAFT ________ BUNO ________

DO NOT WRITE HERE

FLIGHT SURGEON'S REPORT
ESCAPE/EGRESS
OPNAV 3752/8

REPORT SYMBOL
OPNAV 3752-1

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I. LOCATION IN AIRCRAFT (crew/passenger seating)

A. Location
1. ______ Cockpit (pilot/copilot compartment)
2. ______ Navigator/Engineer Compartment
3. ______ Cabin/Passenger Compartment
4. ______ Other
9. ______ Unknown

B. Longitudinal Location
1. ______ Forward
2. ______ Center
3. ______ Aft
9. ______ Unknown

C. Lateral Location
1. ______ Center
2. ______ Left Side
3. ______ Right Side
9. ______ Unknown

D. Direction Facing
1. ______ Forward
2. ______ Aft
3. ______ Sideward
9. ______ Unknown

E. Use of Seat
1. ______ Not in Seat
2. ______ In Seat
3. ______ Bunk/Litter
9. ______ Unknown

II. ESCAPE (see instructions for definition of terms)

A. Method

1. Ejection
1. ______ Accomplished (free of cockpit)
2. ______ Initiated (did not clear cockpit)
3. ______ Attempted (not initiated)
4. ______ Seat Ejected on Impact With Terrain
5. ______ Inadvertent Ejection
6. ______ Underwater Ejection
7. ______ Unknown if Attempt Was Made
8. ______ Suspected Ejection
9. ______ Definitely Not Attempted

2. Bailout
1. ______ Accomplished (free of aircraft)
2. ______ Attempted (not accomplished)
3. ______ Bailed Out After Ejection Attempt Failed
4. ______ Unknown if Attempt Was Made
5. ______ Suspected Bailout
6. ______ Definitely Not Attempted

3. Other
1. ______ Standard Emergency Ground Egress
2. ______ Underwater Egress (not ejection)
3. ______ Did Not Escape
4. ______ Exit Unassisted (other than #1)
5. ______ Carried/Assisted Out
6. ______ Blown/Thrown Out
7. ______ Jumped/fell from A/C (airborne)
8. ______ Unknown if Escape Accomplished
9. ______ Escape Method Unknown

F. Sequence of Actions Performed Prior to Egress
1. ______
2. ______
3. ______
4. ______
5. ______
6. ______
7. ______
8. ______
9. ______

B. Intent for Escape
1. ______ Intentional
2. ______ Unintentional, Self-induced
3. ______ Unintentional, Mechanical
4. ______ Unintentional, Other-induced
9. ______ Intent Unknown

C. Communications Prior to Escape
1. ______ Distress Signal Transmitted
2. ______ Position Fix Transmitted
3. ______ Emergency IFF (manual)
4. ______ Emergency IFF (automatic)
5. ______ None
6. ______ Other
9. ______ Unknown

D. Order of Escape ______ of ______

E. PREVIOUS EJECTIONS/BAILOUTS
Number of Ejections ______
Number of Emergency Bailouts ______
Other Parachute Jumps (training/sky diving etc.)
______
______

III. COCKPIT/CABIN CONDITION AFTER IMPACT

1. ______ Aircraft Abandoned in Flight
2. ______ [illegible]
3. ______ [illegible]
4. ______ [illegible]
5. ______ [illegible]
6. ______ [illegible]
9. ______ Unknown

IV. TERRAIN OF PARACHUTE LANDING OR CRASH SITE (more than one may be applicable)

A ______ Open Sea
B ______ Large Lake
C ______ River
D ______ Deep Water, Other
E ______ Shallow Water
F ______ Deep Snow
G ______ Thick Ice
H ______ Marsh/Swamp/Mud
I ______ Soft Ground
J ______ Building
K ______ Flight Deck
L ______ Dense Woods
M ______ In Trees
N ______ Ravine/Steep Slope
O ______ Rocks
P ______ In/Near Fireball
Q ______ Desert
R ______ Through Trees
S ______ Hard Ground
T ______ Not Applicable/Aircraft Landed Normally
U ______ Runway
V ______ Unknown
Z ______ Other (Explain)

NAME OF THIS INDIVIDUAL ______ SSN ______ AIRCRAFT ______ BUNO ______

INSTRUCTIONS FOR COMPLETING OPNAV 3752/8: ESCAPE – EGRESS

I. Indicate where this individual was located at the time of the mishap. If individual was in the passenger or crew compartment of a large aircraft, indicate approximate location (forward, center, or aft section). A line drawing with the individual's location marked is desirable in multi-placed aircraft.

II. A.1. "Ejection" is the completion of action by the aircrewmember to initiate the ejection sequence (raising handle, and/or squeezing trigger, and/or pulling face curtain), regardless of the outcome of the action, e.g., an "ejection" includes those cases wherein the sequence is interrupted by ground impact or system malfunction.

A.2. A bailout is an emergency egress with a parachute from an aircraft aloft without the use of an automated aircrew escape system.

A.3. "Other" refers to any type of egress not listed under Ejection or Bailout.

A.4. List the sequence of preparatory actions accomplished by this individual before he/she actually egressed from the aircraft. This information is important for emergency egress training and elaboration of NATOPS changes. Examples would be: visor down, lap belt/shoulder harness straps adjusted, MAYDAY, seat moved/adjusted, tightened mask, crew alert, etc.

II. B,C, and E. Self-explanatory.

D. Give order of egress from aircraft, e.g., first of five (1 of 5), first of one (1 of 1), etc. If unknown, so state.

III. If 1. is checked, an attempt can still be made to ascertain the condition of the cockpit/cabin after impact. This helps determine crash force survivability and cockpit crash worthiness.

IV. Self-explanatory.

DO NOT WRITE HERE

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LIMITED DISTRIBUTION AND SPECIAL HANDLING REQUIRED IN ACCORDANCE WITH OPNAVINST 3750.6

V. AIRCRAFT PARAMETERS AT TIME OF ESCAPE (Either inflight or after crash, ditching, etc.)

1. Altitude ______________ FT (AGL)
2. Airspeed ______________ KIAS
3. Ground Speed ______________ KTS (if not airborne)
4. Sink Rate ______________ FT/MIN
5. Nose Up ______________ °
6. Nose Down ______________ °
7. Right Bank ______________ °
8. Left Bank ______________ °
9. ___ Inverted
10. ___ Nose Down Spin
11. ___ Flat Spin
12. ___ Oscillating Spin
13. ___ Tumbling
14. ___ Mushing
15. ___ Disintegrating
16. ___ Rolling
17. ___ Other (describe) ______________
18. ___ Unknown
19. Rate of Roll ______________ °/SEC.
20. Rate of Pitch ______________ °/SEC.
21. Rate of Yaw ______________ °/SEC.
22. ___ *G Forces: (Estimate number and vector) ______________

*If G forces were a factor during the mishap/egress phase, explain briefly below. Discuss fully on 3752/11. ______________

____

____

____

VI. EGRESS PROBLEMS (Place X in appropriate column)

B. Before; D – During; A – After (Egress)

		Ground			Water			Air			
		B	D	A	B	D	A	B	D	A	
1. Buffeting	01										01
2. *G Forces	02										02
3. Windblast	03										03
4. Seat Left in "Safed" Condition	04										04
5. Difficulty Locating Canopy Jettison Mechanism	05										05
6. Hampered by Clothing	06										06
7. Hampered by Equipment (include body armor)	07										07
8. Hampered by Injuries	08										08
9. Difficulty Releasing Canopy/Hatch	09										09
10. Failure to Release Canopy/Hatch	10										10
11. Face Curtain Failed to Activate Seat	11										11
12. Face Curtain Problem (locating, reaching, etc.)	12										12
13. Lower Ejection Handle Failed to Activate Seat	13										13
14. Lower Ejection Handle Problem (locating, etc.)	14										14
15. Canopy Jettison Problem	15										15
16. Canopy Jettison Failure (automatic means)	16										16
17. Could Not Open Canopy/Hatch	17										17
18. Difficulty Releasing Restraints	18										18
19. Difficulty Reaching Hatch/Exit – Obstructions	19										19
20. Difficulty Reaching Hatch/Exit – Injuries	20										20
21. Difficulty Reaching Hatch/Exit – Aircraft Attitude	21										21
22. Difficulty Reaching Hatch/Exit – Equipment Hangup	22										22
23. Pinned in Aircraft (other than equipment hangup)	23										23
24. Confusion/Panic/Disorientation	24										24
25. Darkness/No Visual Reference	25										25
26. Fire/Smoke/Fuel	26										26
27. Anthropometric Problem	27										27
28. Personal Equipment Factor (other than hangup)	28										28
29. Upper Extremities Hit Cockpit Structures	29										29
30. Lower Extremities Hit Cockpit Structures	30										30
31. Man Struck Canopy/Canopy Bow	31										31
32. Struck External Surface of Aircraft	32										32
33. Flailing – Upper Extremities	33										33
34. Flailing – Lower Extremities	34										34
35. Drogue Slug Swinging	35										35
36. Drogue Slug Struck Man	36										36
37. Man Struck by Other Equipment	37										37
38. Seat/Man Collision	38										38
39. Seat Separation Difficulty	39										39
40. Seat/Parachute Entanglement	40										40
41. Parachute Riser Interference	41										41
42. Man Entangled in Raft Lanyard	42										42
43. Parachute Line Over/Inversion/Semi-Inversion	43										43
44. Man Held onto Seat	44										44
45. Tumbling/Spinning (man and/or seat)	45										45
46. Parachute Container Did Not Open	46										46
47. Parachute Canopy Streamed/Malfunctioned	47										47
48. Inadvertent Opening of Lap Belt	48										48
49. Failure of Lap Belt to Open	49										49
50. Inrushing Water	50										50
51. Cold	51										51
52. Unconscious/Dazed	52										52
53. Other (explain)	53										53

VII. REMARKS OR CONTINUATION: (List number and letter of each egress problem marked and briefly explain each. Continue on a separate sheet, if necessary.)

NAME OF THIS INDIVIDUAL ______________ SSN ______________ AIRCRAFT ______________ BUNO ______________

INSTRUCTIONS FOR COMPLETING OPNAV 3752/8: ESCAPE – EGRESS

V. Fill in or check the spaces to accurately describe the condition of the aircraft at the time of the escape. Indicate the approximate degrees of pitch and bank. If straight and level, enter "0" degrees. Check all parameters necessary to adequately describe condition at escape.

VI. Complete for all aircraft occupants who experienced egress difficulties. Normally, only one section will apply: e.g., in the air, on the ground, or on or underwater. There will be cases when problems were experienced in preparation for egress while still airborne, or on the ground or in the water. However, problems checked must relate to the egress attempt, not to the emergency phase preceding the initiation of the escape. The following guidelines apply

"B" – Before Egress – from initiation of egress attempt until the individual is on his/her way out of the aircraft.

"D" – During Egress – from start of movement out of the aircraft until his/her body is outside the confines of the aircraft structure.

"A" – After Egress – from outside of the aircraft until he/she reaches the ground or water (if inflight egress), or until he/she is clear of all parts of the aircraft (if on ground or in water).

VII. Remarks and/or explanation(s) of any egress problems here.

DO NOT WRITE HERE

FLIGHT SURGEON'S REPORT
EJECTION OR BAILOUT
OPNAV 3752/9

REPORT SYMBOL
OPNAV 3752-1

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I. TIME FROM EMERGENCY UNTIL ESCAPE ATTEMPT WAS INITIATED

Hours______ Minutes______ Seconds______

II. DELAY IN INITIATING ESCAPE DUE TO:

a.
____ 1. Avoiding Populated Area
____ 2. Avoiding Unsuitable Terrain
____ 3. Insufficient Altitude
____ 4. Excess Altitude
____ 5. Excess Airspeed
____ 6. Adverse Aircraft Attitude
____ 7. Adverse Body Position
____ 8. None
____ 9. Unknown
____ 10. Other (describe) ________________

b. ____ Delayed Decision to Eject Because Attempting to Overcome Problem

III. PROTECTIVE HELMET/O_2 MASK

	CHIN STRAP FASTENED			HELMET VISOR LOWERED			O_2 MASK FASTENED (BOTH SIDES)		
	YES	NO	UNK	YES	NO	UNK	YES	NO	UNK
1. Before Emergency									
2. During Egress									
3. During Landing									
4. During Rescue									

IV. EJECTION ENVELOPE.

____ 1. Within the Envelope
____ 2. Outside the Envelope
____ 3. Possibly Outside Envelope (marginal)
____ 9. Unknown

V. REMOVAL OF AIRCRAFT CANOPY:

A. INTENT

____ 1. Intentional
____ 2. Unintentional, Self-induced
____ 3. Unintentional, Mechanical
____ 9. Unknown

B. INITIATED BY

____ 1. This Individual
____ 2. Another Individual
____ 3. Other ____________
____ 9. Unknown

C. REMOVAL

____ 0. Definitely Not Attempted
____ 1. Jettisoned Successfully
____ 2. Attempted (unsuccessful)
____ 3. Unknown if Attempted
____ 4. Ejected Through Canopy
____ 5. Complete Cutting of Glass
____ 6. Partial Cutting of Glass

D. METHOD

____ 1. Ejection Sequence
____ 2. Manually Unlocked
____ 3. Canopy Jettison Handle
____ 4. External Force (explain) ____________
____ 8. Other ____________
____ 9. Unknown

VI. METHOD OF EJECTION INITIATION

____ 1. Arm Rest
____ 2. Face Curtain
____ 3. Lower Ejection Handle
____ 4. Command Sequencer
____ 5. Impact
____ 6. Fire
____ 7. Mechanical Malfunction/Failure
____ 8. Other External Force (explain) ____________
____ 9. Unknown

VII. BODY POSITION AT EJECTION (As compared to optimal)

		A. Head	B. Hips	C. Feet	D. Elbows
Optimal	1				
Forward	2				
Upward	3				
Lateral	4				
Unknown	9				

VIII. POSITION OF EJECTION SEAT

____ 1. Full Up
____ 2. Full Down
____ 3. Intermediate Position
____ 9. Unknown

IX. METHOD OF SEPARATING MAN FROM SEAT

____ 0. Did Not Separate
____ 1. Automatic (as designed)
____ 2. Manual Override
____ 8. Other (describe) ________________

X. METHOD OF DEPLOYING PARACHUTE

____ 0. Not Deployed
____ 1. Automatic (as designed)
____ 2. Manual
____ 8. Other (describe) ____________
____ 9. Unknown

XI. PARACHUTE OPENING SHOCK

____ 0. Negligible
____ 1. Moderate
____ 2. Severe
____ 9. Unknown

XII. OSCILLATIONS	0-Negligible	1-Moderate	2-Severe	9-Unknown
A. During descent prior to 4-line release system actuation.				
B. During descent after 4-line release system actuation.				
C. During descent without 4-line release system installed/actuated.				
D. Accentuated by seat survival kit deployment				

XIII. PARACHUTE DAMAGE (Give number of)

1. Severed Suspension Lines ______
2. Missing Panels ______
3. Torn Panels-Major ______
4. Torn Panels-Minor ______

XIV. CAUSE OF PARACHUTE DAMAGE

____ 1. Opening Shock
____ 2. Fouled on Ejection Seat
____ 3. Fouled on Aircraft
____ 4. Fire
____ 5. Landing
____ 6. Trees
____ 7. Dragging
____ 8. Other (Describe) ____________
____ 9. Unknown

NAME OF THIS INDIVIDUAL ________________ SSN __________ AIRCRAFT __________ BUNO ________

INSTRUCTIONS FOR COMPLETING OPNAV 3752/9: EJECTION OR BAILOUT

An Ejection/Bailout Episode is the sequence of events beginning with the ejection/bailout initiation and ending after parachute landing.

I. – Time commences from the moment that the aircrewmember recognized that an ejection/bailout situation existed. Use "est" for estimated if actual times cannot be determined. In many mishaps, an emergency does not warrant an immediate attempt to leave the aircraft; instead, an emergency landing, ditching, etc., may be attempted. When this proves futile due to recognition of deterioraton of the situation (e.g., flameout, loss of control, realization that runway cannot be reached, etc.), a decision to escape is made. Give the time from this recognition until escape attempt was initiated.

II. A. There may be one or more reasons for delaying the initiation of escape. If known, provide these in numerical sequence (1,2,3...).

B. Refers only to the period of time before ejection decision.

III. – Self-explanatory

IV. – As defined in the aircraft's NATOPS manual. (Check only one block)

V. – This section is designed to show how and by whom the canopy was removed. Ejection through the canopy means literally *through the canopy glass.* Complete or partial cutting of the glass (V. C. 5&6) refers to the action of canopy fracturing systems. Consult NAVAIR 11-100-1 technical manual and ejection seat specialists (paraloft) for assistance.

VI. – If ejection was initiated by ground impact or mid-air collision, check block #5. If ejection was initiated by windblast, etc., check block #8 and explain.

VII. – The optimal body position for ejection is: head against headrest, chin slightly elevated, hips all the way back, feet on the rudder pedals, heels on the deck and elbows tucked in. Check the appropriate boxes to indicate in what direction these parts of the body were displaced from the optimal, or to indicate that the body parts were in optimal position.

VIII., IX. & X. – Self-explanatory

XI. – Based on the survivor's statements and/or your judgment.

XII. – Based on the survivor's/witnesses' statements.

XIII. – Consider a panel missing if the damage is so severe that it is totally ineffective as a means of deceleration, even though remnants are still attached to the edges of the panel. Identify gores and panels by number and letters based upon information in NAVAIR 13-1-6.2 Personnel Parachute Manual. Use this information to fill in parachute damage chart (obtainable from paraloft.)

XIV. – More than one cause may apply. Number in sequence, if known. Parachute engineers (e.g. NAVWPNCEN (Code 64) China Lake) should be consulted prior to determination, when possible.

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XV. DIRECTION FACED AT PARACHUTE LANDING WITH RESPECT TO HORIZONTAL TRAVEL

___1. Directly Facing ___4. Quartering, Back

___2. Facing Away ___5. Directly Sideways

___3. Quartering, Facing ___9. Unknown

XVI. LANDING CONDITIONS

1. Surface Winds:______Knots.
2. Dragged by Chute:____Yes____No
3. Distance/time dragged:_____Yards_____Sec.
4 Underwater utilization of emergency oxygen: ___Yes ____No

XVII. CANOPY DEFLATION POCKETS (Water landing only)

___0. Not Effective in Collapsing Chute ___8. Unknown if Installed

___1. Aided in Collapsing Chute ___9. Unknown if Effective

___7. Not Installed

XVIII. SEQUENCE OF ACTIONS ACCOMPLISHED BEFORE LANDING

	USE	ORDER		USE	ORDER
A. Life Preserver Actuated			F. 4-line Release System Actuated		
B. Survival Kit Deployed			G. Parachute Canopy Release Actuated		
C. Life Raft Actuated (if not auto)			H. Helmet Visor Raised		
D. O_2-Mask Removed			I. Other (describe) ____________		
E. Gloves Removed					

XIX. SEQUENCE OF ACTIONS ACCOMPLISHED AFTER LANDING

	USE	ORDER		USE	ORDER
A. Life Preserver Actuated			F. Boarded Liferaft		
B. Survival Kit Deployed			G. Parachute Canopy Release Actuated		
C. Life Raft Actuated (if not auto)			H. Helmet Visor Raised		
D. O_2 Mask Removed			I. Other (describe) ____________		
E. Gloves Removed					

XX. PARACHUTE ACTUATION DURING BAILOUT

___A. Automatic Parachute Actuator Lanyard Connected ___C. Other (Describe) ____________________

___B. Parachute Actuated Manually (D-Ring) ____________________

XXI. REMARKS List number and letter of each item marked above and briefly explain each item.

NAME OF THIS INDIVIDUAL____________________ SSN____________ AIRCRAFT________ BUNO________

INSTRUCTIONS FOR COMPLETING OPNAV 3752/9: EJECTION OR BAILOUT

XV. – Show direction the individual was facing with respect to the horizontal travel over the surface.

XVI. – Use "est." if an estimate.

XVII. – Self-explanatory

XVIII. & XIX. – In the column "use," enter one of the following letters, as appropriate: **Y** – yes, **F** – attempted/failed, **N** – not attempted, **U** – unknown/not applicable. In the column "order," enter the number **1,2,3,** etc. to indicate the order in which the action was accomplished or attempted. If the survival kit or 4-line release was deployed before parachute landing, indicate in the "Remarks" section specifically when they were deployed and effect deployment had on parachute oscillations, if any.

XX. – Self-explanatory (complete only for bailouts).

XXI. – Briefly explain answers that are not covered adequately by the blocks available on the form. If appropriate, describe the individual's physical state just prior to landing in terms of altered consciousness or impaired ability to perform a Parachute Landing Fall (PLF) or water landing.

DO NOT WRITE HERE

FLIGHT SURGEON'S REPORT
SURVIVAL AND RESCUE
OPNAV 3752/10

REPORT SYMBOL
OPNAV 3752-1

**THIS IS PART OF A LIMITED USE NAVAL AIRCRAFT MISHAP INVESTIGATION REPORT.
LIMITED DISTRIBUTION AND SPECIAL HANDLING REQUIRED IN ACCORDANCE WITH OPNAVINST 3750.6.**

I. CONDITIONS PREVAILING AT SURVIVAL/RESCUE SITE (if widely variable, give range)

A. Temperature/Winds/Waves

1. Water Temperature _____ °F
2. Air Temperature _____ °F
3. Surface Winds _______ Knots
   _______ °
4. Wave Height _______ Feet
5. Wave Frequency _____ Per Minute

B. Terrain

____ 1. Open Ground ____ 6. Ice/Snow
____ 2. Woods/Jungle ____ 7. Swamp
____ 3. Mountains ____ 8. Other
____ 4. Desert ____ 9. Unknown
____ 5. Water

C. Weather

____ 1. Clear ____ 6. Sleet
____ 2. Overcast ____ 7. Hail
____ 3. Fog ____ 8. Other
____ 4. Rain ____ 9. Unknown
____ 5. Snow

II. TIME LAPSE SEQUENCE FOR ACTUAL RESCUE VEHICLES/PERSONNEL

	ACTUAL RESCUER (24 HOUR CLOCK)	ELAPSED TIME	LIGHT CONDITIONS (Check applicable column)			
			DAWN	DAY	DUSK	NIGHT
A. Rescue personnel notified that mishap had occurred						
B. Rescue vehicle departed						
C. This individual located by rescue personnel						
D. This individual physically reached by rescue vehicle personnel						
E. This individual actually in rescue vehicle or rescue attempt abandoned						
F. Rescue completed (Person returned to station, hospital, etc.)						

III. TIME THIS INDIVIDUAL SPENT: A. IN WATER ___ HRS ___ MIN B. IN LIFE RAFT ___ HRS ___ MIN

IV. PERSONNEL/VEHICLES PARTICIPATING IN RESCUE

A. Vehicle Performing Actual Pickup of This Person.

1. Organization ____________
2. Type/Model ____________
3. Location When Alerted ____________
4. Duty When Alerted ____________
5. Miles from Rescue Vehicle/Personnel to Victim(s) (straight-line distance) ________
6. Actual Miles Rescue Vehicle/Personnel Traveled ____________

B. SAR Report Information

1. SAR Report Attached ☐ Yes ☐ No
2. If #1 is "No", SAR Report Number ______
3. Report Available from (activity) ______

C. Did Rescue Personnel Leave Vehicle to Assist in Rescue?
1. Yes ____ 2. No ____ → If yes, how?

___ A. Parachuted ___ D. Lowered by Hoist
___ B. Jumped Without Parachute ___ E. Normal Ground/Water
___ C. Descended Line/Ladder/Net ___ Y. Other ________

V. ASSIST VEHICLES THAT ATTEMPTED RESCUE

A. Organization ____________
B. Type/Model ____________ C. Experienced Problems: Yes ____ No ____ (If yes, comment in REMARKs section)
D. List Other Vehicles Participating in Rescue Effort or Who Stood by Ready to Render Assistance If Required:
1. ____________
2. ____________
3. ____________

VI. RESCUE ALERTING MEANS (Use numbers to show sequence)

___ A – Witnessed
___ B – Radar Surveillance
___ C – Overdue Report to SAR
___ D – Airborne Rapid Relay
___ E – Crash Phone
___ F – Other Telephone
___ G – Radio MAYDAY Call
___ H – Survival Radio
___ I – Other Radio Report
___ J – Visual Signaling Equipment
___ K – Audio Signaling Equipment
___ L – Survivor Report
___ M – Loss of Radio Contact
___ N – Smoke/Fire/Crash Scene
___ Y – Other (Describe) ________

VII. ALERTING COMMUNICATIONS PROBLEMS

___ A – Poor Radio Reception
___ B – Telephone Line Busy
___ C – Poor Radio Discipline
___ D – Aircraft Radio/IFF Equipment Inoperative
___ E – Poor Radio Procedures
___ F – Language Problems
___ G – Incompatible Radio Frequency
___ H – None
___ Y – Other ____________

NAME OF THIS INDIVIDUAL ____________ SSN ________ AIRCRAFT ________ BUNO ________

INSTRUCTIONS FOR COMPLETION OF OPNAV 3752/10: SURVIVAL AND RESCUE

I More than one condition may prevail under A, B, and C.

II Take care in completing this section. Report all times as local. Elapsed time begins from the moment rescue personnel are first notified. The length of time that a survivor is exposed to environmental hazards before aid arrives forms the basis for a great deal of research in Aviation Life Support Systems (ALSS).

III. Do not count time in the raft as part of the time in the water. A total of A plus B should represent total time from water entry until rescue. If the individual abandons his raft for rescue, this time is part of A.

IV. A. Pertains only to the vehicle that performed the actual rescue. Title of organization effecting the rescue is, e.g., HS-1, Sheriff's Department, etc. If civilian, list name and address. The rest of this section is self-explanatory.

V: A, B, and C: This is a rescue vehicle/person that was physically capable of making the rescue but did not for some reason. Example: a helo that developed a problem with the hoist and stood by while a motor whale boat made the rescue.

D: Refers to vehicles, other than that listed in A, B, and C that participated or could have participated in a rescue attempt.

VI Indicate how rescuers/units were alerted to the need for a rescue effort. Include all active participants.

VII. Include all active participants' problems.

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VIII. DELAYS IN DEPARTURE OF RESCUE VEHICLE(S)

___ 1. Vehicle Operator Not Available
___ 2. Vehicle Not Ready
___ 3. Vehicle Crew Not Available
___ 4. Communications Breakdown
___ 5. Completing Previously Assigned Duties
___ 6. Lack of Information on Crash Site
___ 7. Nature of Terrain
___ 8. Weather
___ 9. None
___ 98. Other ______________________

IX. RESCUE VEHICLE PROBLEMS ENROUTE

___ 1. Headwind
___ 2. Poor Visibility
___ 3. High Sea State
___ 4. Mechanical Problems
___ 5. Nature of Terrain
___ 6. Other Obstructions (Fences, etc.)
___ 7. Rescuers Lost
___ 8. Weather
___ 9. None
___ 98. Other ______________________

X. PROBLEMS IN LOCATING INDIVIDUAL OR KEEPING INDIVIDUAL IN SIGHT

___ 1. Heavy Seas
___ 2 Trees
___ 3. Fog/Clouds
___ 4. Precipitation
___ 5. Darkness
___ 6. Radio Interference
___ 7. Confusion Due to Other Lights
___ 8. Malfunction of Directional Equipment
___ 9. Lack of Correct Information on Location of Survivor
___ 10. Inability to Visually Distinguish Survivor from Terrain
___ 11. Loss of Radio/Radar Contact
___ 12. Survivor's Failure to Use Signalling Equipment
___ 13. Inadequate/Improper Search
___ 14. None
___ 98. Other (Describe) ______________________

XI. RESCUE EQUIPEMENT USED

(Use numbers to show sequence)

___ 1. Sling
___ 2. Seat
___ 3. Cargo Net
___ 4. Rope
___ 5. Life Ring
___ 6. Basket
___ 7. Boom Net
___ 8. Davit
___ 9. Raft
___ 10. Webbing Cutters
___ 11. Torso Harness D-Ring
___ 12 Grapnel
___ 13. Boarding Ladder
___ 14. Knife/Axe/Saw
___ 15. Makeshift Carrier/Support
___ 16. First Aid Equipment
___ 17. Tree Penetrator Seat
___ 18. Helicopter Platform
___ 19. Stretcher
___ 20. Cable Cutters
___ 21. Helicopter Rescue Boom
___ 22. Billy Pugh Net
___ 98. Other (Describe) ________ ______________________

XII. SURVIVAL PROBLEMS ENCOUNTERED BY THIS PERSON (Number in the sequence experienced)

___ 01 Inadequate Flotation Gear
___ 02 Inadequate Cold Weather Gear
___ 03 Lack of Signalling Equipment
___ 04 Lack of Other Equipment
___ 05 Entanglement (Parachute)
___ 06 Dragging (Parachute)
___ 07 Parachute Hardware Problem
___ 08 Entrapment in Aircraft
___ 09 Pulled Down by Sinking Parachute
___ 10 Entanglement (Other than Parachute)
___ 11 Unfamiliar with Procedures/Equipment
___ 12 Confused, Dazed, Disoriented
___ 13 Incapacitated by Injury
___ 14 Poor Physical Condition
___ 15 Exposure (Heat, Cold, Sunburn)
___ 16 Fatigue
___ 17 Weather
___ 18 Topography (Swamps, Mountains, Deserts, etc.)
___ 19 Darkness
___ 20 Thrown Out of Raft
___ 21 Hampered by Helo Downwash
___ 22 Problem Boarding Rescue Vehicle
___ 23 Thirst
___ 24 Hunger
___ 25 Insects, Snakes, Animals, etc.
___ 26 Sharks
___ 27 Proximity to Ship (________ Yards)
___ 28 Hampered by Injuries
___ 29 None
___ 98 Other (Describe) ______________________

NAME OF THIS INDIVIDUAL ______________________ SSN ____________ AIRCRAFT ____________ BUNO ________

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XIII. PROBLEMS THAT COMPLICATED RESCUE OPERATIONS

___ 01 Failure of Rescue Vehicle (Mechanical Problems)
___ 02 Inadequacy/Lack of Rescue Vehicle
___ 03 Failure of Rescue Equipment (Hoist, etc.)
___ 04 Inadequacy/Lack of Rescue Equipment
___ 05 Inadequacy of Rescue Personnel Knowledge/Training
___ 06 Inadequate Medical Equipment
___ 07 Inadequate Medical Facilities
___ 08 Vehicle Operator Factor (Poor Procedures)
___ 09 Rescue Crewman Assist Hesitancy
___ 10 Fire/Explosion
___ 11 Entrapment in Aircraft
___ 12 Physical Limitations of Rescue Personnel
___ 13 Physical Limitations of Person Being Rescued
___ 14 Carelessness of Rescue Personnel
___ 15 Panic/Inappropriate Actions of Person Being Rescued
___ 16 Rescue Vehicle Accident
___ 17 Communications Problems
___ 18 Drag/Entanglement by Deployed Parachute
___ 19 Topography (Rough Seas, Mountains, etc.)
___ 20 Interference From Other Vehicles
___ 21 Victim Pulled Away by External Forces
___ 22 Weather
___ 23 Darkness
___ 24 Weight/Drag Problem Not Due to Parachute
___ 25 Hampered by Personal/Survival Equipment of Person Being Rescued
___ 26 Floating Debris
___ 27 Primary Rescuer Delayed Awaiting Futile Attempts by Other Rescuers
___ 28 Hampered by Helicopter Downwash
___ 29 Inadequate Training of Person being Rescued
___ 30 Inadequate Knowledge of Aircraft Emergency Escape Means
___ 31 Inadequate Knowledge of Personal Equipment Releases/Actuators
___ 32 Inadequate Rescue Procedures/Pre-Mishap Plans
___ 33 Poor Availability of Rescue Equipment
___ 34 Poor Suitability of Rescue Equipment
___ 35 Poor Survivor's Techniques
___ 36 Poor Coordination of Rescue Efforts
___ 37 None
___ 98 Other (Describe) ______________________

XIV. INDIVIDUAL'S PHYSICAL CONDITION	DURING RESCUE	AFTER RESCUE
1. Fully Able to Assist		
2. Partially Able to Assist		
3. Immobile or Unconscious		
4. Fatal on Recovery-Due to Injuries		
5. Fatal on Recovery-Drowned		
6. Recovered Alive-Died From Injuries		
7. Lost During Rescue Attempt-Apparently Injured or Drowned		

XV. LOCATOR MEANS (Actual Rescue Vehicle, see instructions)

MEANS	ROLE	PROBLEM	MEANS	ROLE	PROBLEM	MEANS	ROLE	PROBLEM
1.			7.			13.		
2.			8.			14.		
3.			9.			15.		
4.			10.			16.		
5.			11.			17.		
6.			12.			18.		

XVI. REMARKS (Indicate item referred to. Continue on separate sheet, if necessary)

NAME OF THIS INDIVIDUAL ______________ SSN ______________ AIRCRAFT ______________ BUNO ______________

INSTRUCTIONS FOR COMPLETION OF OPNAV 3752/10: SURVIVAL AND RESCUE

XIII: Pertains *only* to the vehicle that performed the actual rescue. If another vehicle experienced problems, these should be commented on in the REMARKS section. The problems and conditions listed here should be checked if present. A condition which does not affect the outcome of today's rescue may result in a loss of life tomorrow. (Interpretation of this item is in direct contrast to Section XII above, which stresses individual reaction rather than potential hazard.)

XIV: Check appropriate columns concerning survivor's/victim's condition.

XV: The following covers Naval signaling devices, as well as general locator means. This list is very specific as to method/device. Accurate reporting of these methods/devices is of paramount importance, since evaluation and improvement of these items are constantly being conducted. Consult Life Support Equipment Specialists for accurate nomenclature of these locators. Since new devices are constantly becoming available, this list may not be all-inclusive. Indicate any additional locator means which are not on the list if applicable to this individual. List the devices in the order they were actuated. Use following codes for locator means.

LOCATOR MEANS CODES

GENERAL

01. Mishap observed.
02. Crash scene located without aid of signaling or personal equipment.
03. Individual sighted without aid of signaling or personal equipment.
04. Survivor located rescuers.

ELECTRONIC SIGNALING DEVICES

05. Radio/radar vector or DF steer.
06. AN/URT-26.
07. AN/PRC 112.
10. RT-10.
11. RT-10 Dual Channel.
13. AN/PRT-5.
19. AN/PRC-63.
20. AN/PRC-63 Beacon only.
21. AN/PRC-63 Dual/Multi-Channel.
22. AN/CRT-3.
23. AN/URT-33.
24. AN/PRC-90.
25. RT-60.

PYROTECHNICS

26. Flare, MK-13-Mod 0.
27. Smoke, MK-13-Mod 0.
28. Pencil Flare MK-79-Mod 0.
29. Flare MK-124-Mod 0.
30. Smoke MK-124-Mod 0.
32. Pyrotechnic Pistol (Very Pistol).
33. Mini Flare.
34. Mini Smoke.

BALLISTICS

35. .38 Flare (Victory Model).
36. .38 Flare (Air Weight).
37. .38 Tracers.
38. .38 Tracers (Air Weight).

AUDITORY

39. Smith and Wesson (Model 39, 9mm).
40. Gunfire (other).
41. Whistle.
42. Voice.

VISUAL

43. Fire/Smoke (Made by Survivor).
44. Other Aircraft Orbiting Scene.
45. Signals Tramped in Snow, etc.
46. SDU-5/E Strobe Light.
47. SDU-5/E Strobe Light With Shroud.
49. Signal Wand.
50. Smoke Float
52. Smoke Grenade.
53. Flashlight.
54. Mirror.
55. Dye Marker.
56. Raft/Vest/Poncho.
57. Parachute.
58. Helmet.
59. Flight Suit.
60. Reflective Tape.
61. SDU 30.
62. LPP Preserver Light (P/N 68A94C13-1).
63. Other/Explain.

I - The individual experienced difficulty with the use of the device (i.e., familiarity, training, knowledge, injury, etc.)
M - Malfunction of the device.

NOTE. A detailed description and discussion of problems should be given on the Equipment form (OPNAV 3752/7) and on the Analysis form (OPNAV 3752/11), if significant.

Code the role of a particular method/device in the discovery of the survivor/rescuer as follows:

"*P*" – Primary
"*S*" – Secondary

NOTE: Even though a device was utilized more than once, it *shall* be listed again in its proper sequence.

An example follows: An A-7 was heading back to the CV at sunset when it suddenly experienced an engine failure. The pilot ejected before broadcasting a "MAYDAY." On ejection, the URT-33 (243 MHz frequency) beacon (in his seat pan) actuated. Once safely under his parachute, the pilot attempted to contact someone with the PRC-90 radio. The beacon in the seat pan interfered with the transmission. (He had selected 243 on his PRC-90.) His PRC-90 radio was knocked out of his hand on water entry and the pilot lost it. (It was not secured to his MA-2 torso harness pocket.) The pilot boarded his LR-1 liferaft and deployed the sea dye marker and his strobe light. In the distance, a helo approached. The pilot fired off two MK-79 pen flares. He also attempted to use his mirror, even though the sun was setting. (He later learned that the helo crew had seen the flashes from the mirror, causing them to head in his general direction.) As the helo approached, the crew simultaneously saw the sea dye marker and the strobe light. The helo continued its approach. The pilot attempted to give them wind direction information by actuating a MK-13 flare. He accidentally actuated the night end. The second *MK-13 flare failed to actuate and the third one functioned properly. An uneventful rescue followed.*

MEANS	ROLE	PROBLEM	MEANS	ROLE	PROBLEM	MEANS	ROLE	PROBLEM
1 23			7. 54	P				
2 24		I	8. 26		I			
3 55	S		9. 27		M			
4 46	S		10. 27					
5 28								
6 28								

XVI: Self-explanatory. Amplify any item as necessary in space provided or on separate sheet of paper.

FLIGHT SURGEON'S REPORT
ANALYSIS, CONCLUSIONS AND RECOMMENDATIONS
OPNAV 3752-11

REPORT SYMBOL
OPNAV 3752-1
PAGE 1 OF 1

THIS IS PART OF A LIMITED USE NAVAL AIRCRAFT MISHAP INVESTIGATION REPORT.
LIMITED DISTRIBUTION AND SPECIAL HANDLING IS REQUIRED IN ACCORDANCE WITH OPNAVINST 3750.6.

ANALYSIS, CONCLUSIONS AND RECOMMENDATIONS (Continue on separate sheet, if necessary)

FLIGHT SURGEON PARTICIPATED FULLY IN INVESTIGATION _____YES _____NO	NO. OF HOURS SPENT	DATE OF FSR
FLIGHT SURGEON PARTICIPATED FULLY IN BOARD PROCEEDINGS _____YES _____NO	NO. OF HOURS SPENT	TELEPHONE (FLIGHT SURGEON) AUTOVON: _____ COMMERCIAL: _____

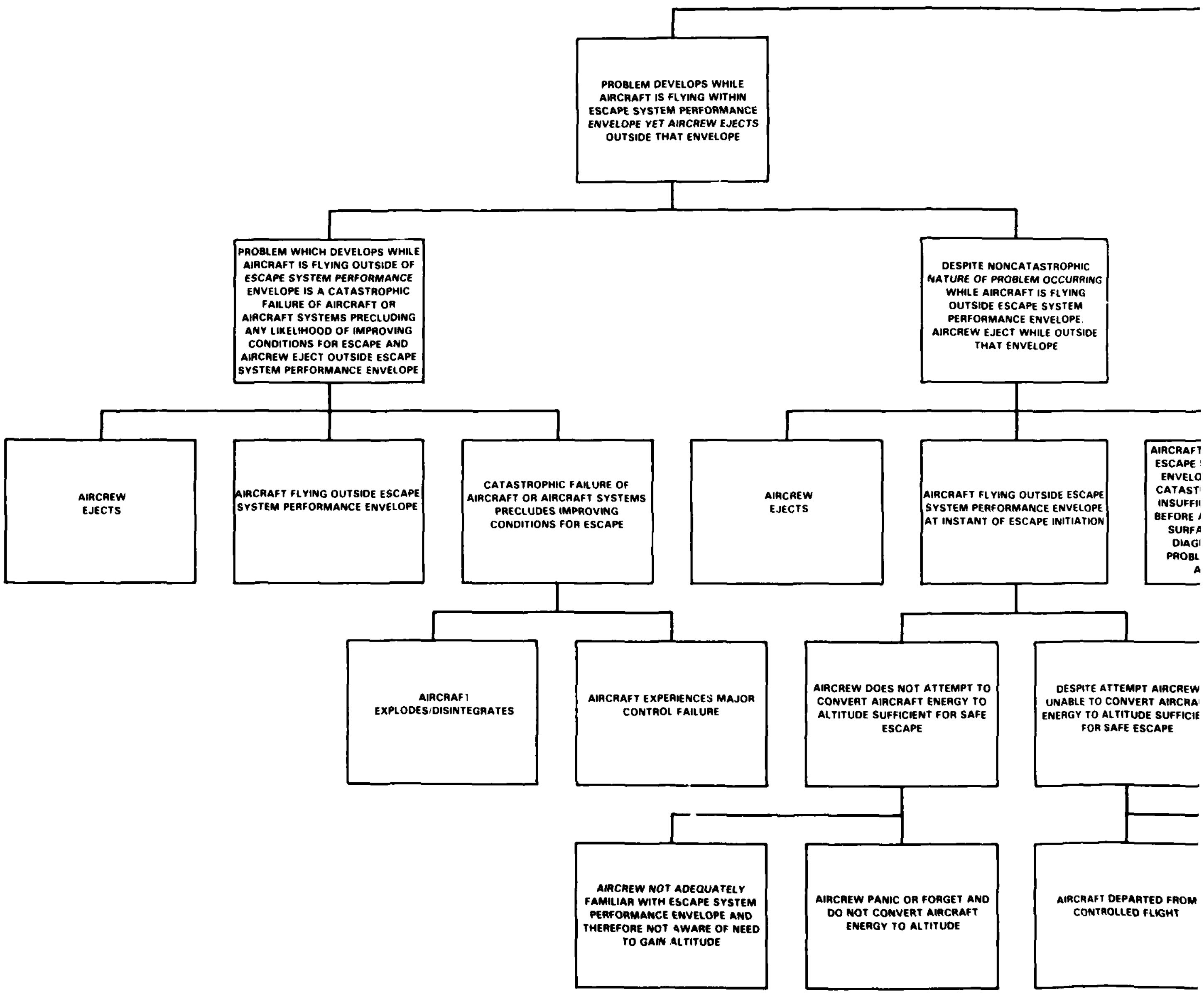
FLIGHT SURGEON'S NAME AND GRADE	DUTY STATION

AMSO OR OTHERS WHO ASSISTED	RANK/GRADE	HOURS SPENT	DUTY STATION	TELEPHONE NUMBER (AMSO) AUTOVON: _____

INSTRUCTIONS FOR COMPLETION OF OPNAV 3752/11: FLIGHT SURGEON'S ANALYSIS CONCLUSIONS AND RECOMMENDATIONS:

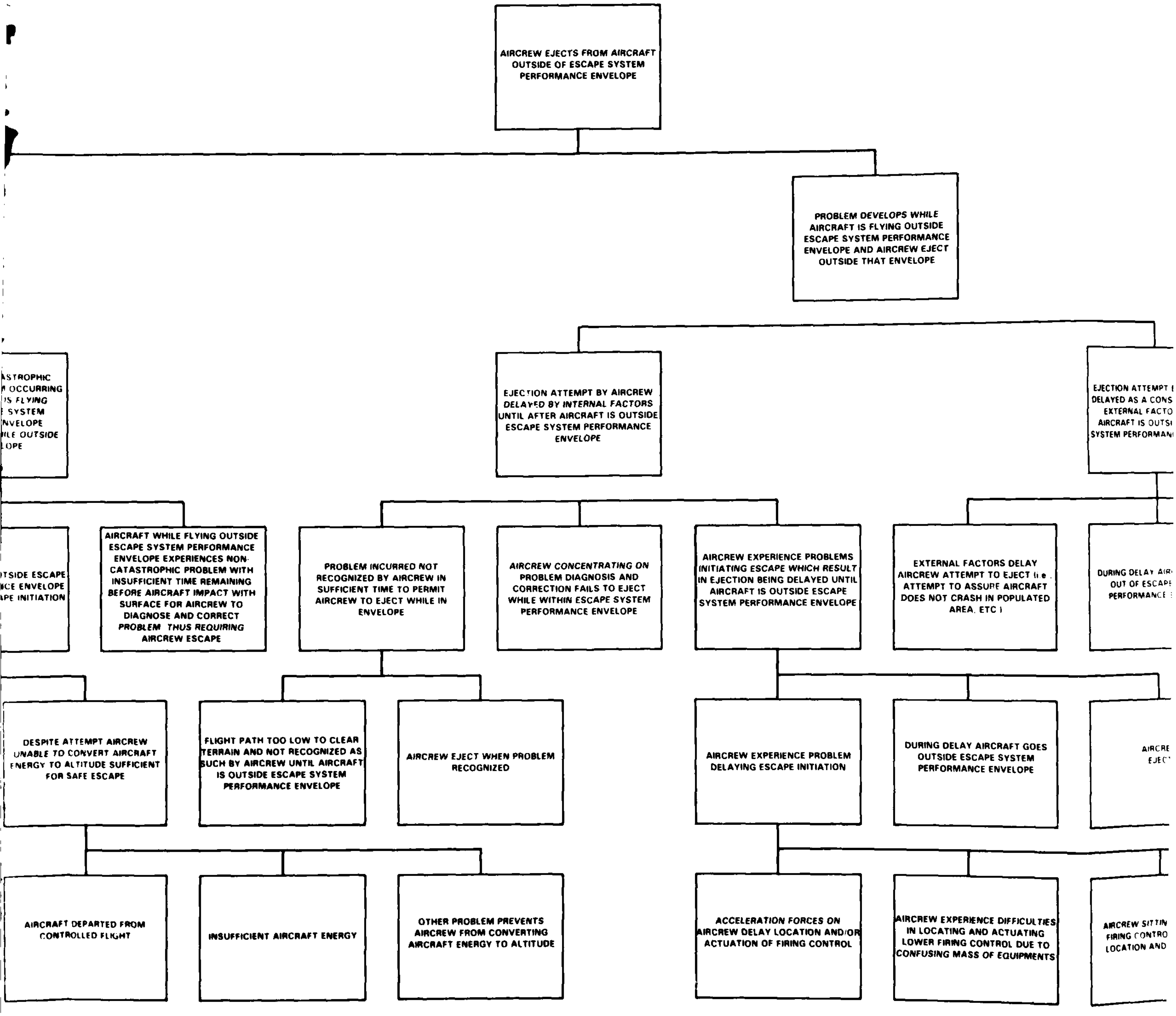
Problems, difficulties, and deficiencies which have been noted on the preceding pages shall be described and analyzed in full here. The analysis shall extend from the time period before the mishap, considering those factors felt to be contributory, to the completion of the entire mishap sequence (e.g., egress, rescue, etc.). It may be as all-encompassing and detailed as necessary. Conclusions and Recommendations shall be based on the analysis and be presented to the entire Aircraft Mishap Board. Conclusions should be brief and address only those topics analyzed. Each recommendation shall be based on a specific conclusion. Where possible, action agencies shall be recommended. If the flight surgeon is not in complete agreement with the *aeromedical* findings or recommendations of the AMB, this difference of opinion shall be documented in this section.

DO NOT WRITE HERE

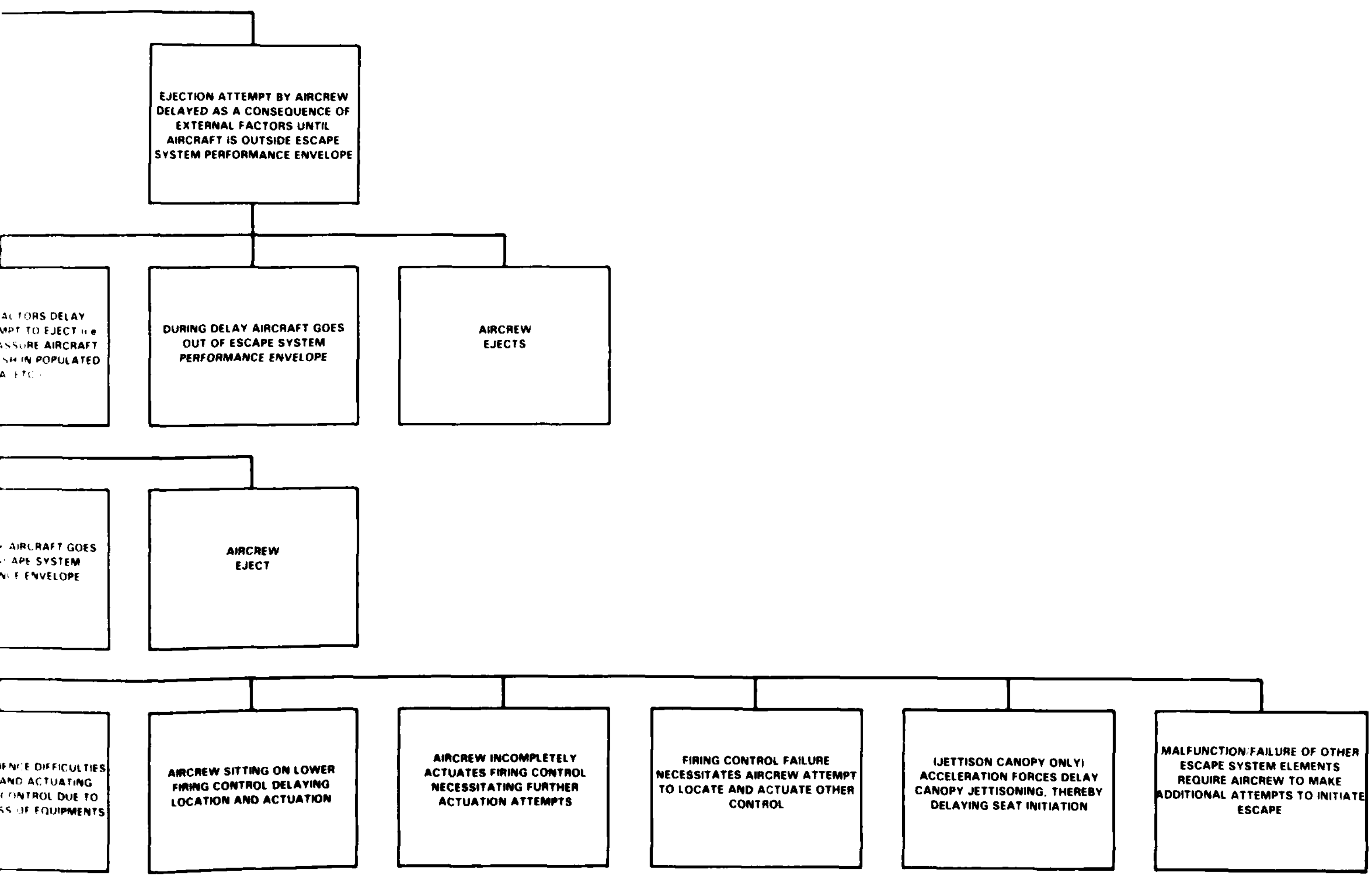

PROBLEM DEVELOPS WHILE AIRCRAFT IS FLYING WITHIN ESCAPE SYSTEM PERFORMANCE ENVELOPE YET AIRCREW EJECTS OUTSIDE THAT ENVELOPE
PROBLEM WHICH DEVELOPS WHILE AIRCRAFT IS FLYING OUTSIDE OF ESCAPE SYSTEM PERFORMANCE ENVELOPE IS A CATASTROPHIC FAILURE OF AIRCRAFT OR AIRCRAFT SYSTEMS PRECLUDING ANY LIKELIHOOD OF IMPROVING CONDITIONS FOR ESCAPE AND AIRCREW EJECT OUTSIDE ESCAPE SYSTEM PERFORMANCE ENVELOPE
DESPITE NONCATASTROPHIC NATURE OF PROBLEM OCCURRING WHILE AIRCRAFT IS FLYING OUTSIDE ESCAPE SYSTEM PERFORMANCE ENVELOPE, AIRCREW EJECT WHILE OUTSIDE THAT ENVELOPE
AIRCREW EJECTS
AIRCRAFT FLYING OUTSIDE ESCAPE SYSTEM PERFORMANCE ENVELOPE
CATASTROPHIC FAILURE OF AIRCRAFT OR AIRCRAFT SYSTEMS PRECLUDES IMPROVING CONDITIONS FOR ESCAPE
AIRCREW EJECTS
AIRCRAFT FLYING OUTSIDE ESCAPE SYSTEM PERFORMANCE ENVELOPE AT INSTANT OF ESCAPE INITIATION
AIRCRAFT EXPLODES/DISINTEGRATES
AIRCRAFT EXPERIENCES MAJOR CONTROL FAILURE
AIRCREW DOES NOT ATTEMPT TO CONVERT AIRCRAFT ENERGY TO ALTITUDE SUFFICIENT FOR SAFE ESCAPE
DESPITE ATTEMPT AIRCREW
FOR SAFE ESCAPE
AIRCREW NOT ADEQUATELY FAMILIAR WITH ESCAPE SYSTEM PERFORMANCE ENVELOPE AND THEREFORE NOT AWARE OF NEED TO GAIN ALTITUDE
AIRCREW PANIC OR FORGET AND DO NOT CONVERT AIRCRAFT ENERGY TO ALTITUDE
AIRCRAFT DEPARTED FROM CONTROLLED FLIGHT

(1)

REASONS FOR OUT-OF-ENVELOPE EJECTION ATTEMPTS

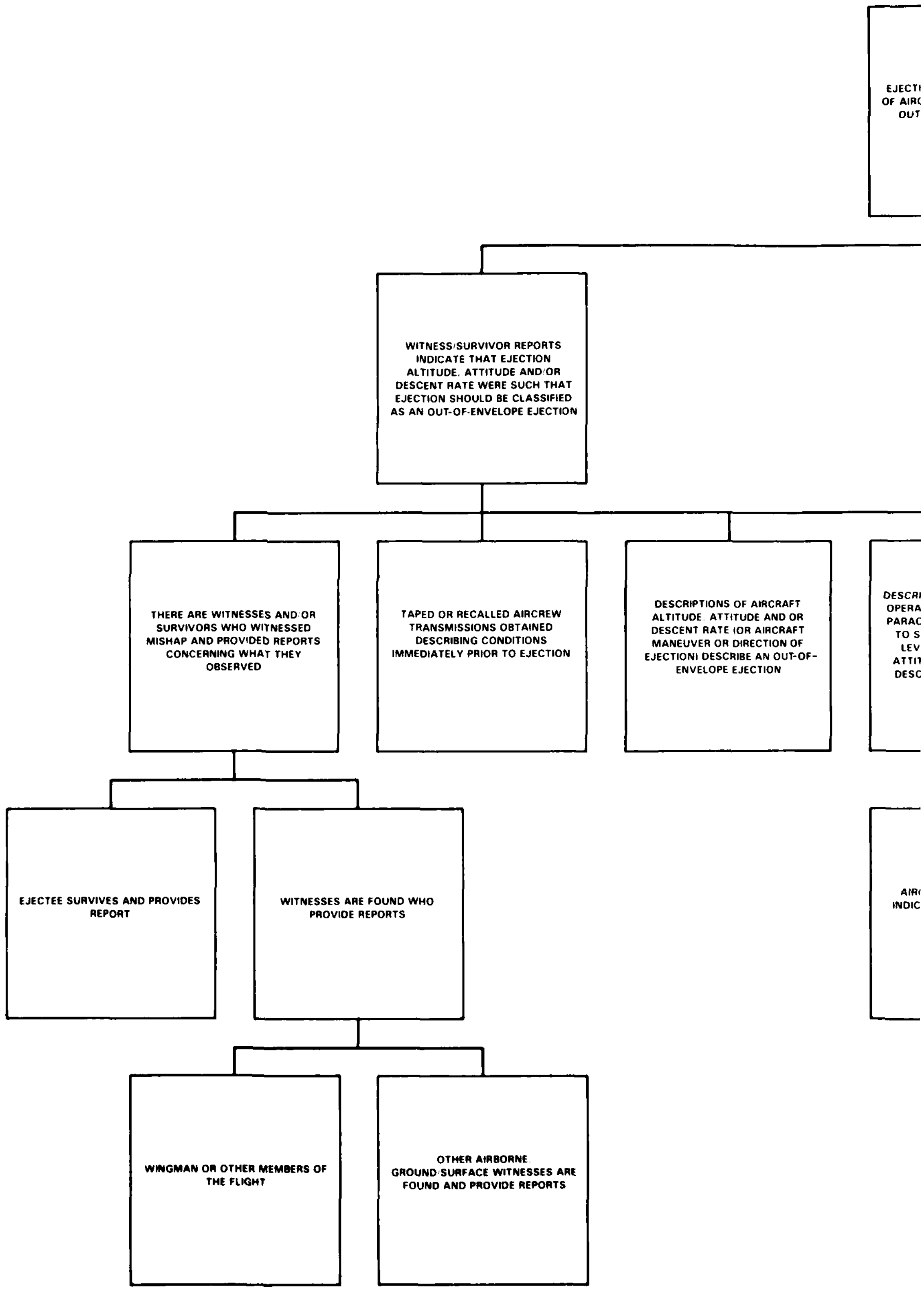


2


EJECTION ATTEMPT BY AIRCREW DELAYED AS A CONSEQUENCE OF EXTERNAL FACTORS UNTIL AIRCRAFT IS OUTSIDE ESCAPE SYSTEM PERFORMANCE ENVELOPE
DURING DELAY AIRCRAFT GOES OUT OF ESCAPE SYSTEM PERFORMANCE ENVELOPE
AIRCREW EJECTS
AIRCREW EJECT
AIRCREW SITTING ON LOWER FIRING CONTROL DELAYING LOCATION AND ACTUATION
AIRCREW INCOMPLETELY ACTUATES FIRING CONTROL NECESSITATING FURTHER ACTUATION ATTEMPTS
FIRING CONTROL FAILURE NECESSITATES AIRCREW ATTEMPT TO LOCATE AND ACTUATE OTHER CONTROL
(JETTISON CANOPY ONLY) ACCELERATION FORCES DELAY CANOPY JETTISONING, THEREBY DELAYING SEAT INITIATION
MALFUNCTION/FAILURE OF OTHER ESCAPE SYSTEM ELEMENTS REQUIRE AIRCREW TO MAKE ADDITIONAL ATTEMPTS TO INITIATE ESCAPE

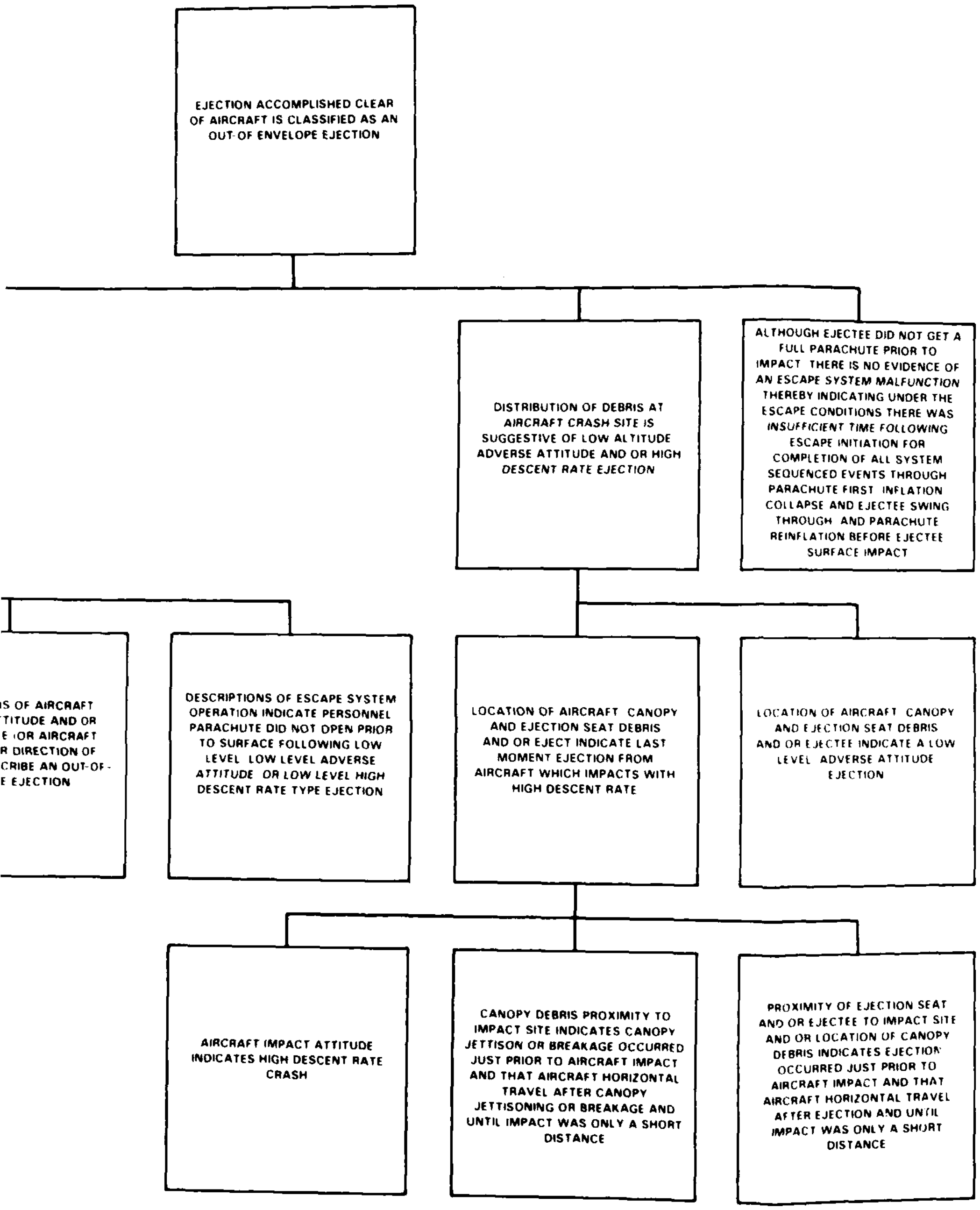
3

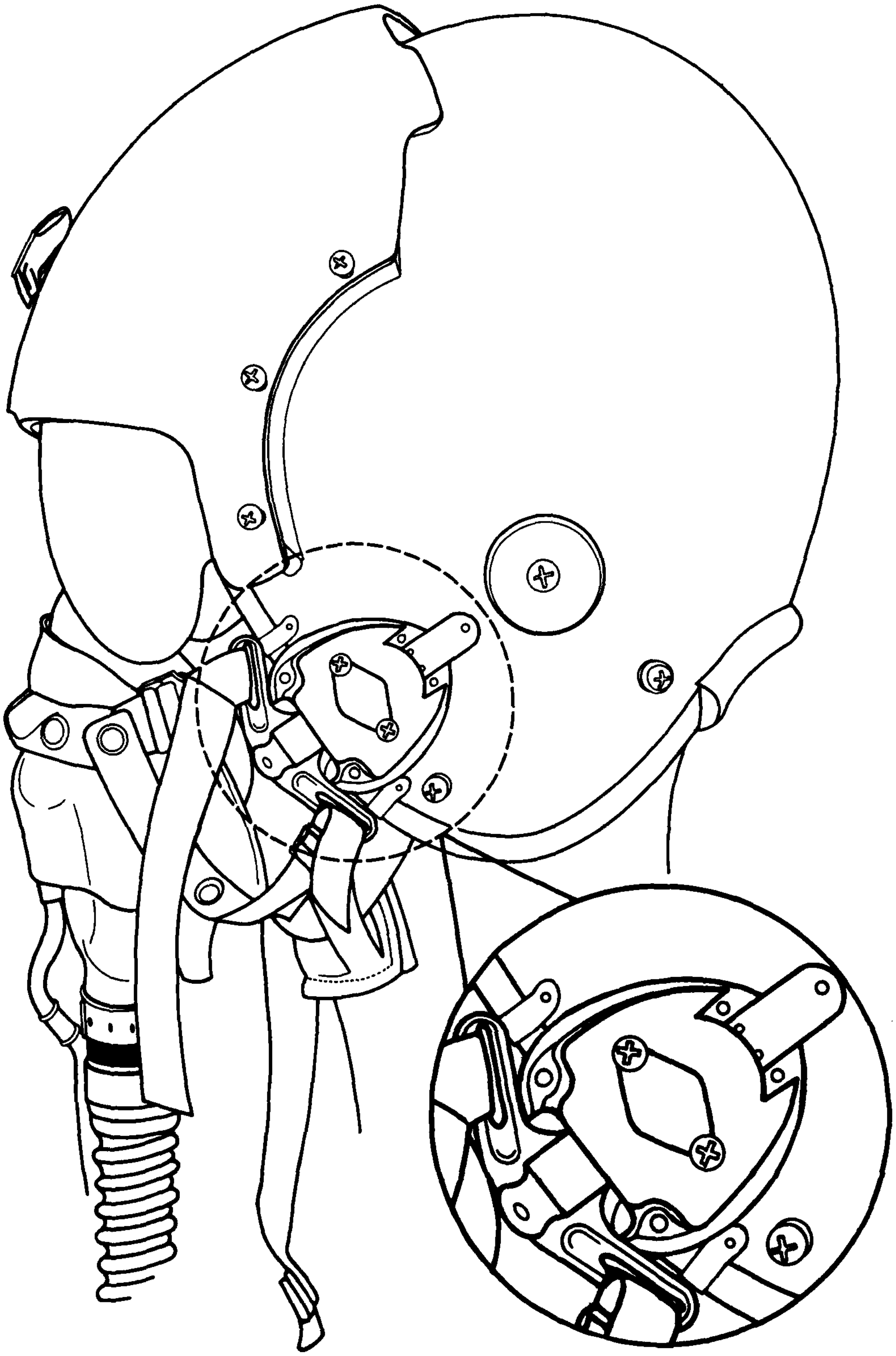
REASONS FOR CLASSIFYING AN EJECT
OUT-OF-

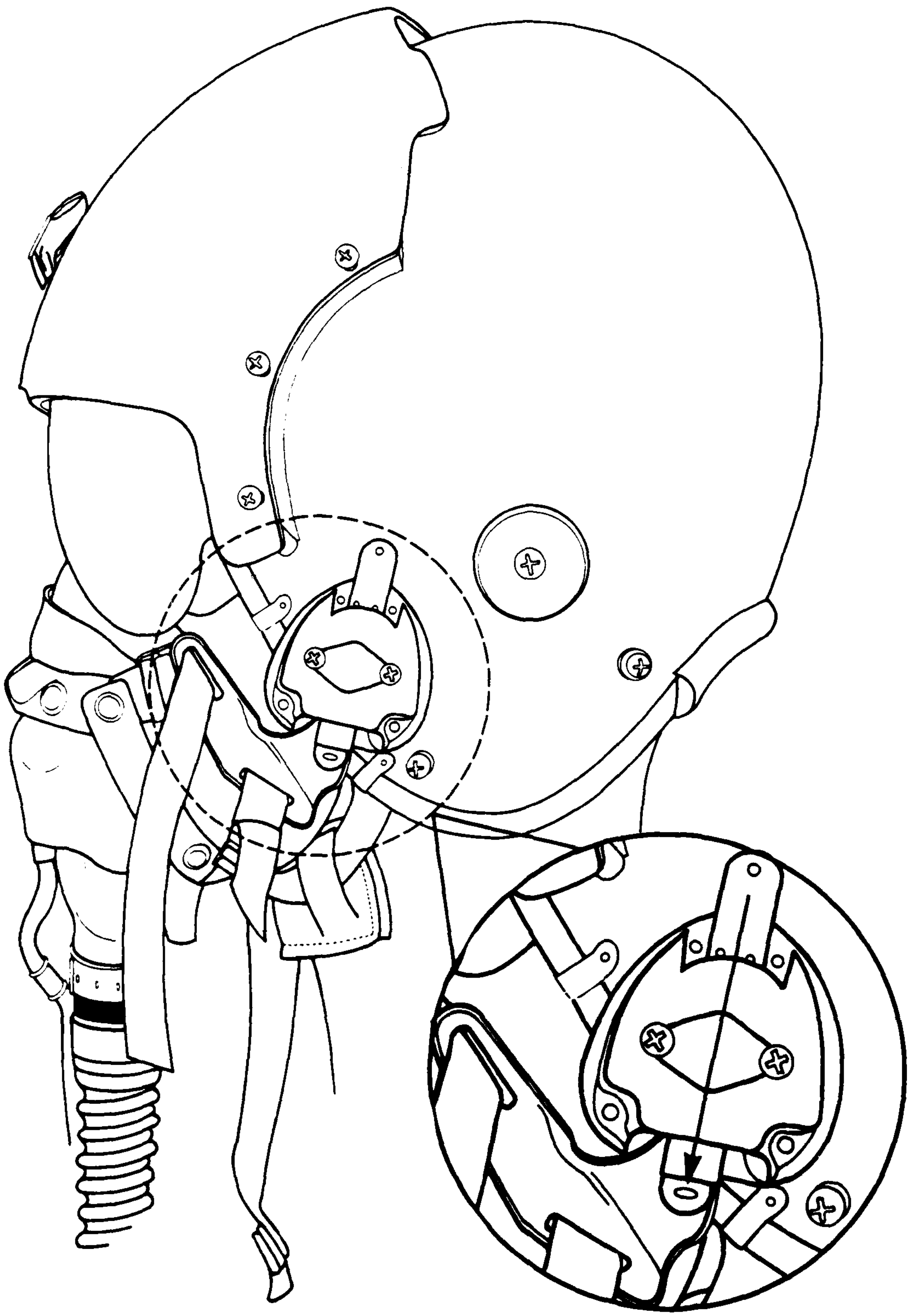


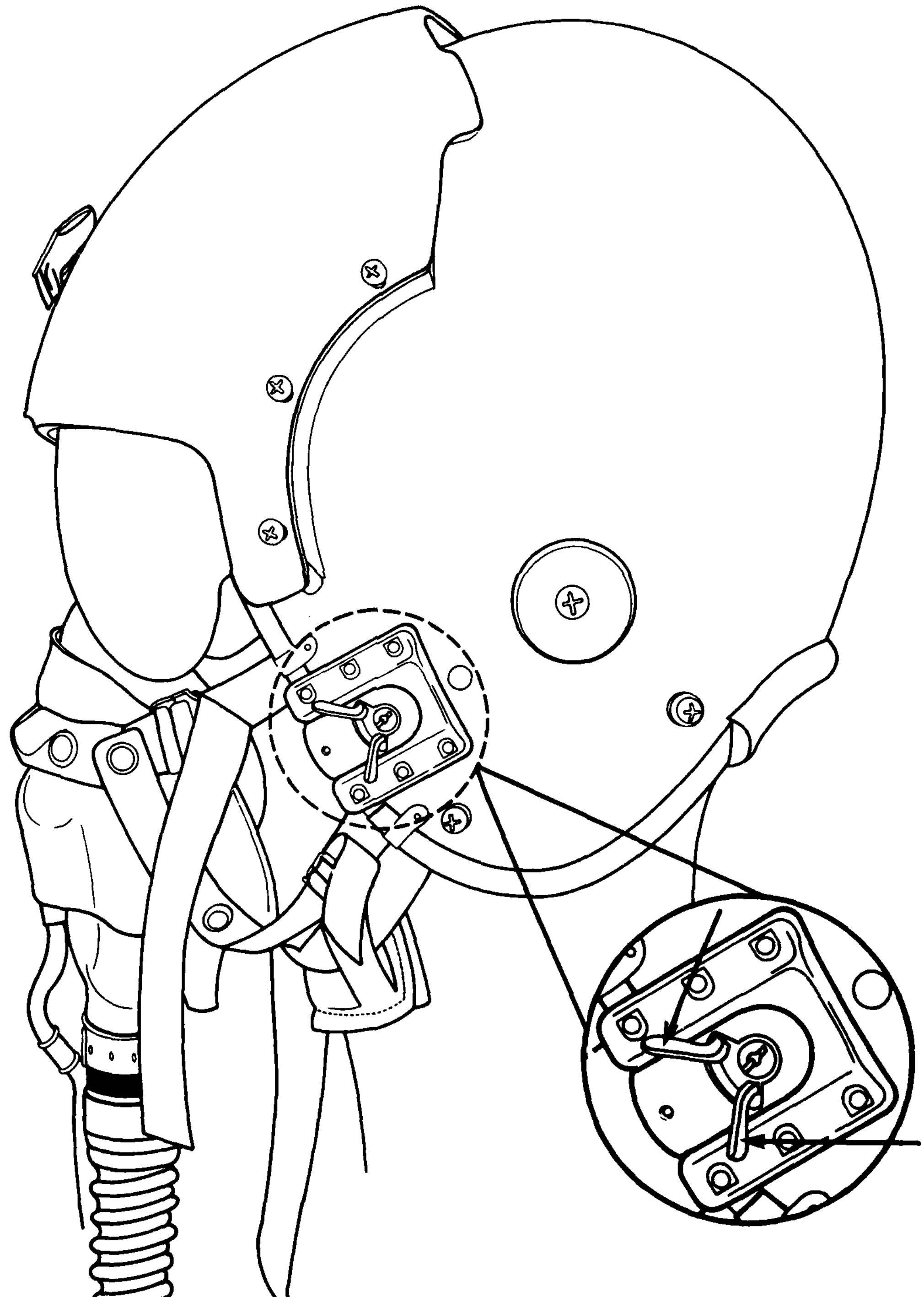
1

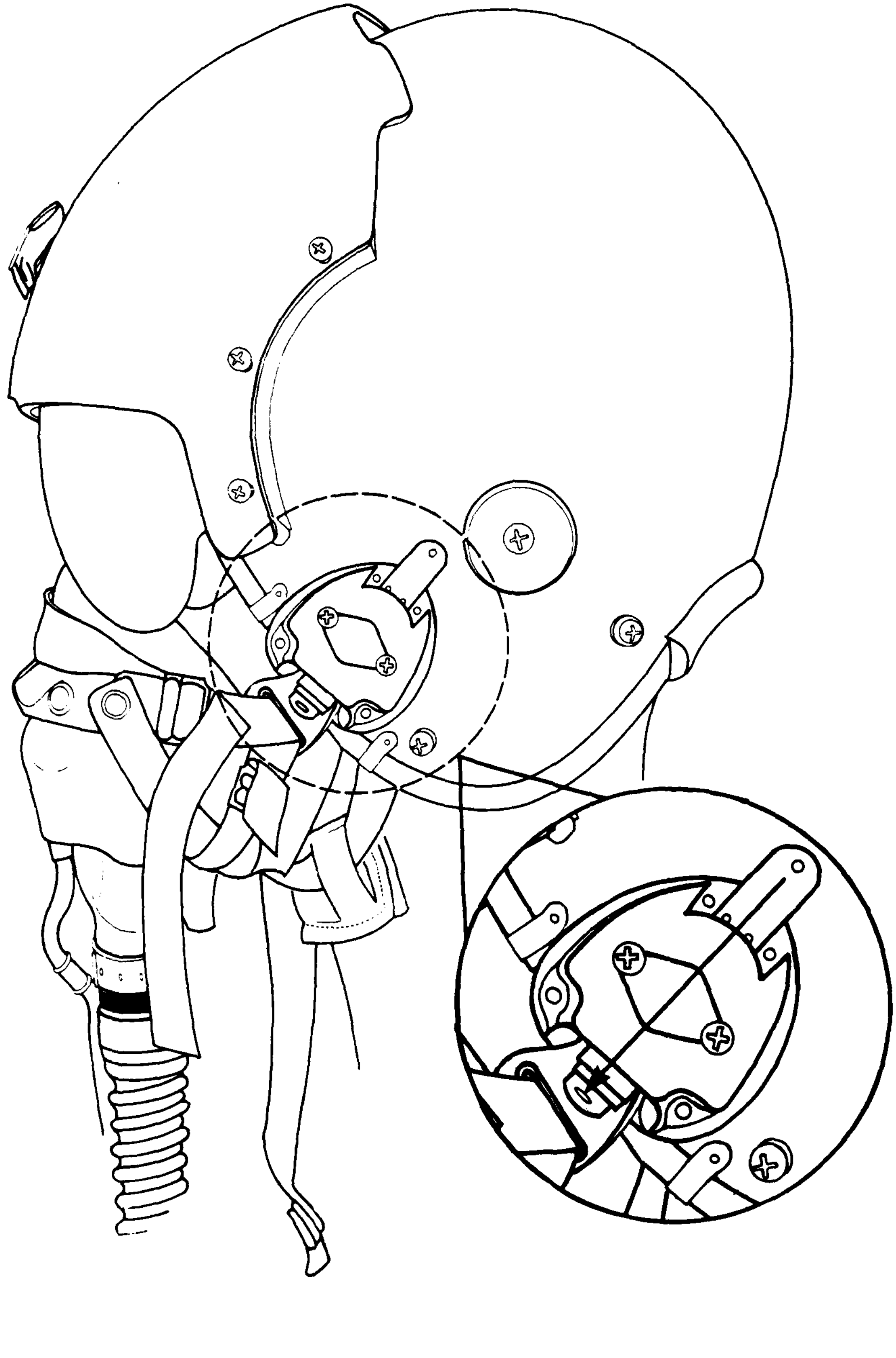
R CLASSIFYING AN EJECTION ACCOMPLISHED CLEAR OF THE AIRCRAFT AS AN OUT-OF-ENVELOPE EJECTION



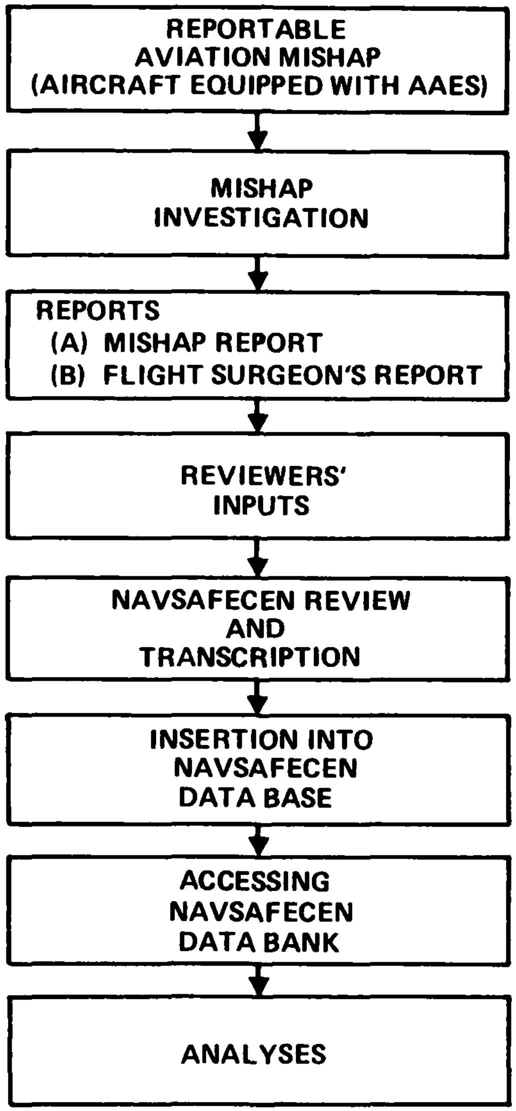




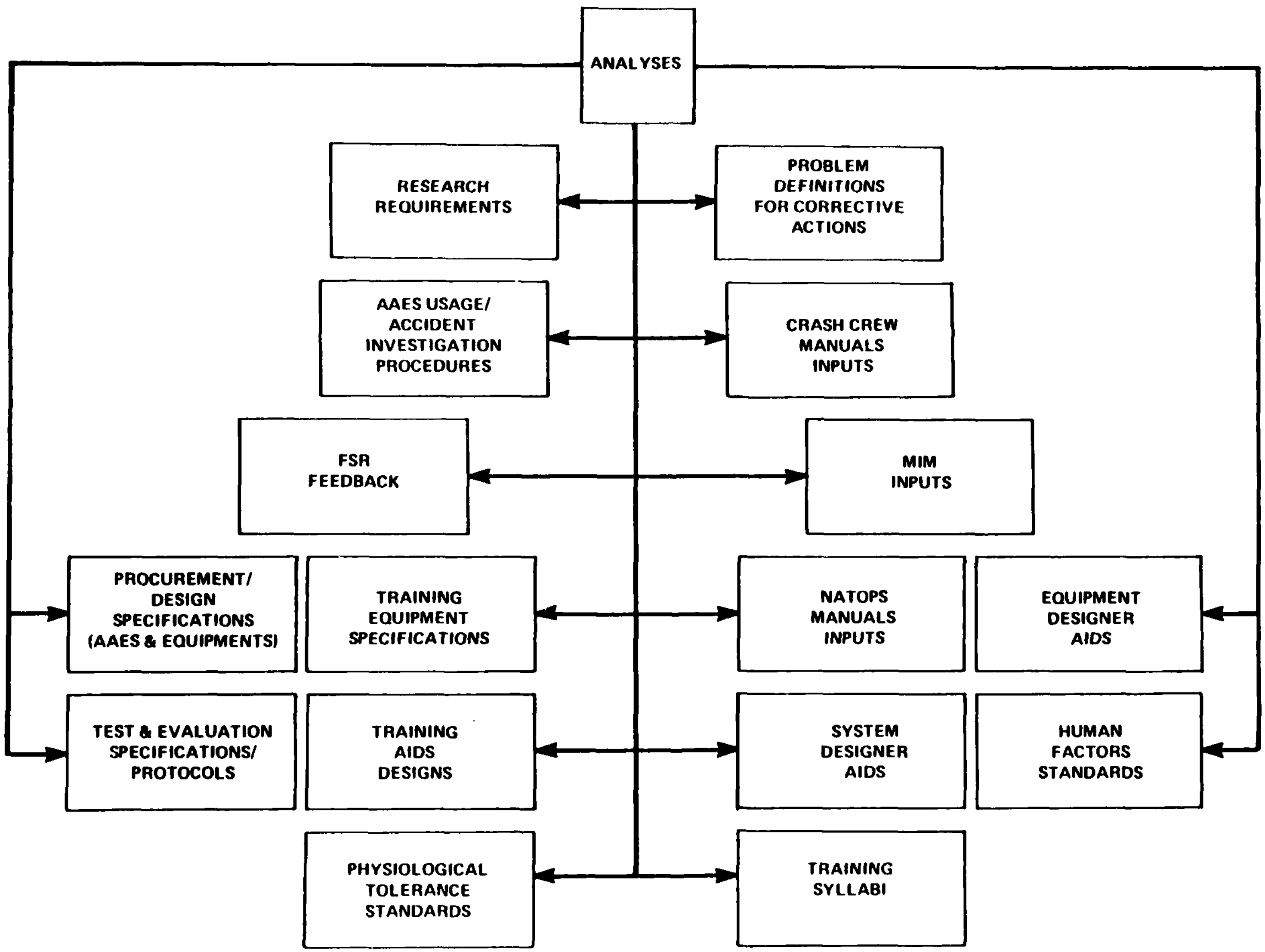




AAES DATA CHAIN



AAES DATA ANALYSES USAGES



PRELIMINARY DRAFT

AIRCREW AUTOMATED ESCAPE SYSTEMS (AAES) IN-SERVICE USAGE DATA ANALYSIS PROGRAM

UPPER LIMB FLAIL QUESTIONNAIRE

1. Date of ejection:________________ Aircraft model________________ Seat type________________
   Nature of emergency requiring ejection________________________________
   ____
   ____

2. Which firing control handle did you use? Upper___Lower___Side___None___(Sequenced/Inadvertent)

3. How many hands were used to grasp and pull handle? One___Two___None___(Sequenced/Inadvertent)

4. If one or both hands were not grasping handle, what were they doing at time of ejection?

   Holding throttle ________
   Holding stick ___(Fwd_____Aft_____Center_____Left_____Right_____)
   Holding onto personal equipment_____(Describe)________________________
   Holding wrist of hand grasping handle________________________
   Free ________________________________

5. Were you wearing flight gloves? Yes_____No_____. If yes, what type (describe)?________________
   ____
   ____

6. Did your arms flail? Yes_____No_____. Left_____Right_____(If no, you need not answer the remaining questions.).
   Did you see them flail? Yes_____No_____. If you did not see them flail, what were the indications of arm flail? (Describe)________________________________
   ____
   ____
   ____
   ____
   ____

   Describe, if you can, the flail behavior of each arm, particularly direction of arm motions (forward, aft, laterally, down, up; forward then down; up then aft; etc.)________________________
   ____
   ____
   ____
   ____

   Did either arm (which) contact anything while flailing? Yes_____No_____Which________________

   Describe, if you can, your attitude with respect to wind when flailing first occurred (facing, feet into, head into, back towards, sidewards, etc.).________________________
   ____
   ____
   ____
   ____

   Were you tumbling (Rolling___Yawing___Pitching___Combined___) Before___or During___(Neither___) when arm flail was experienced?

   Describe any other aspect of arm flailing you recall such as when in sequence, forces experienced, etc.
   ____
   ____
   ____
   ____
   ____
   ____
   ____

PRELIMINARY DRAFT

AIRCREW AUTOMATED ESCAPE SYSTEMS (AAES) IN-SERVICE USAGE DATA ANALYSIS PROGRAM

POST-EGRESS TUMBLE QUESTIONNAIRE

1. Date of ejection:________________ Aircraft model________________ Seat type________________
   Nature of emergency requiring ejection ____
   ____
   ____

2. Which firing control handle did you use? Upper____Lower ____Side____None____(Sequenced/Inadvertent)
   ____

3. How many hands were used to grasp and pull handle? One____Two____None____(Sequenced/Inadvertent)
   ____

4. If one or both hands were free, did either or both flail? Yes____No____. If yes, which? Left ____Right____, and in what direction? Forward_____Up_____Lateral_____Down_____ Aft_____

5. Did you experience tumbling? Yes ____ No____. If yes, what indications did you have that you were tumbling? Visual________________Other________________ (Describe)________________
   ____
   ____
   ____

IF TUMBLING WAS NOT EXPERIENCED, YOU NEED NOT ANSWER THE REMAINING QUESTIONS

6. Did tumbling occur before or after separation from seat? Before_____After_____Both____________

7. Did tumbling occur before or after personal parachute opening? Before_____ After________________

8. Did tumbling involve one or more complete revolutions or only a partial revolution? One_____More____ Partial_____.

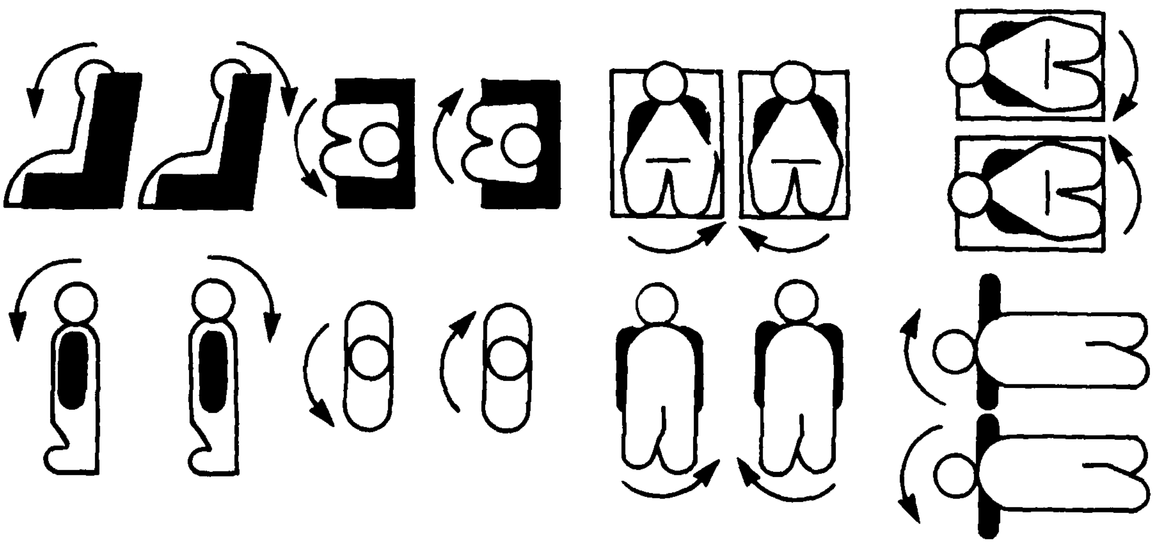
9. Did tumble involve:

   PITCH: Forward_____ Aft_____Forward then aft_____ Aft then forward__________

   YAW: Left_____Right_____Left then right_____Right then left______________

   ROLL: Left_____Right_____Left then right_____ Right then left______________

10. Select sketch/sketches best depicting tumble you experienced or provide sketch/sketches. If more than one sketch is selected, number them in sequence of occurrence:



Aircrew Life Support Systems (ALSS), Post Emergency Usage

Guides

Part I: Aircrew Protective Helmets

INTRODUCTION

Aircrew protective helmets are designed to reduce the likelihood and severity of head injuries resulting from impact with objects in the aircrew environment. Helmets are employed as mounting platforms for targeting, communications and oxygen systems. Current helmet designs provide impact protection and sound attenuation while functioning as the mounting platform for the variety of components listed above and other components depending upon the aircraft community.

Currently, there are questions concerning the need for the ballistic protection in fixed winged aircraft and whether the weight associated with present helmets may contribute to neck injuries. There is a requirement for an accurate and indepth analysis of each aircraft accident to clarify and define the injury mechanisms and determine the injury trends associated with various combinations of life support equipment and aircraft communities. These injuries may result from interaction of the helmet and man, helmet and escape system components, or helmet and the parachute. Detailed analysis of the accidents will improve the understanding of what the helmet incurs with each injury and help establish accurate injury trends.

Thorough investigation of, and accurate record of, each accident is essential to provide the data base necessary for statistical and engineering analysis of the mishap event sequence associated with accidents occurring within various naval aviation communities and to define the interactions which occur. To clearly define the problems and standardize data acquisition associated with aircraft accidents, it is necessary to introduce systematic analytical procedures to evaluate aircrew life support equipment involved in accidents regardless of the injuries to the aircrew. The acquisition of this data allows for the continuing evaluation and appraisal of the equipment and its performance and interactions with the aircrew. Further systematic analysis of the accidents will clarify causal relationships within the accident environment and indicate injury producers and suggest preventive techniques which may be useful.

To begin the development of procedures for ensuring and enhancing the systematic analysis of the aircrew equipment, the helmet evaluation was selected for the development of evaluation guidelines. It is necessary to document the conditions and circumstances of use, damage and abuse of the helmet before, during and post accident, extent and location of the damage, pattern of the damage and injury to the aircrewman, indicators of the damage to the helmet and injury to the aircrewman. The damage patterns may provide data necessary to define peculiar interactions which may endanger the aircrewman during ejection sequences or during other aviation emergencies. Non-destructive inspection techniques are selected to provide data for evaluation while retaining the equipment intact. Despite the focus on and interest in the identification and documentation of damage and wearer injury as the circumstances attendant to their occurence, a

very critical need exists for the equally careful identification and documentation of lack of damage or wearer injury and the circumstances attendant to their occurrences. This information can aid in identifying those conditions for which the equipment performs satisfactorily and thereby help put damage and wearer injury into proper perspective. From this data, equipment interactions and performance can be assessed and design requirements defined or redefined for future equipment development or modification of present systems to reduce the likelihood of the introduction of additional risk, or increase the existing risk, of injury severity and frequency.

To define the environment in which the helmet is used and effects upon (1) user's safety, (2) protective capability, and (3) helmet integrity, all helmets involved in aircraft accidents/mishaps shall be subjected to Non-Destructive Inspection (Phase I). If peculiar conditions or unusual helmet behavior is identified, further inspections should be conducted in greater detail. The Phase II Non-Destructive Inspection will provide an enhanced visual inspection of the helmet to describe and identify the damage patterns and extent of the damage. Should this inspection indicate the need for further testing, then Phase III Destructive Inspection may be selected to aid the analysis of the accident and damage.

This handbook provides guidance for Phase I and II procedures and includes a worksheet format and the supporting information required for the investigation and analysis of the accident data. The supporting information will assist the investigators in determining if Phase III Inspection is warranted and how this inspection should proceed. The information contained within the helmet report format (1) will be combined with all available data acquired on damage patterns associated with accidents and testing; (2) shall be provided to the investigating medical officer for the aircraft accident; and (3) will be employed to update the design criteria and quality assurance assessment standards for helmets, helmet mounted equipment, and other appropriate subcomponents of the system.

The procedures established by this document have been implemented by the enclosed OPNAVINST and amendments which provide for systematic acquisition and analysis of aircraft accident data to develop information for reducing the potential risk to the aircrewman. Failure to completely institute systematic "in-service" data acquisition and analysis can result in valuable data being overlooked and lost thereby introducing bias into the informational system.

The issuance of this handbook is accompanied by the enclosed OPNAVINST, which requires that all helmets employed in ejections or other aircraft mishaps be subjected to systematic inspection designed to provide (1) full documentation of the conditions attendant to the helmet's usage, (2) identification and cataloguing of damage to the helmet and its subcomponents, (3) identification and documentation of all head and neck injuries sustained by aircrewman, (4) comparison of the damage patterns under varying conditions, (5) comparison of the injury patterns resulting under comparative conditions with the associated helmet damage, and (6) determination of the protective efficiency of the helmet in preventing impact injuries to the head. This OPNAVINST also sets forth conditions where Phase III Destructive Inspection is necessary.

Should Phase III Inspection be indicated, guidelines for shipping of the equipment will be provided and the appropriate destination indicated. Receipt of the equipment will be acknowledge using a form letter which will contain the receipt of the helmet, indicate the time in which to expect a response, and the inspection procedures to be employed.

Suggested photographic data and views are represented in Appendix F. It is suggested that either 8x10 color or black and white photographs be used to most effectively indicate the damage or strains. These photographs should be crisp and clear and a notation made on the reverse as to the suspected damage on interactions indicated as requested in Appendix B. Line drawings should be used liberally to enhance damage documentation and to support your hypotheses and analysis. Additionally, give all the data as accurately and completely as possible, and do not be fearful of not having any clear hypothesis.

WORK SHEET

Appendix A

A. Data required for all life support equipment

1. Date of accident   Accident I.D. No.

2. Type of aircraft   Bureau No.

3. Location of accident

4. Ejection   Yes____   No_____

If yes: a.   Altitude

b.   Airspeed

c.   Attitude

d.   Ejection seat type Ser. No

e.   Crew station

f.   Parachute

g.   Survival kit type

h.   Reported winds aloft in area

i.   Landing site

5. Crash (occupied)   Yes_____   No_____

a.   Altitude of impact site

b.   Estimated airspeed at impact

c.   Estimated attitude at impact

d.   Impact site (ground - water - flight deck)

e.   Wind conditions

B. Injuries Sustanined: Fatal_________   Nonfatal________

1. Overall injuries reported (FSR):

2. Specific injuries: (a)   Head fx   Yes__   No__

(b)   Neck fx   Yes__   No__

(c) Neck strain/sprain Yes__ No__

(List type and location of injuries using anatomical landmarks. Describe how the injury was determined - X-ray, postmortem, etc.)

C. Personal data: (1) Age ____ Blood Type ____

(2) Sex ____

(3) Weight ______

(4) Height ______

(5) Anthropometric Measurements

(a) Total Sitting Height _____

(b) Neck Circumference _______

(c) Cervical Length (C1 thru C7) ________

(d) Head Circumference _________

(e) Buttock Knee Length ________

(f) Buttock Popiteal Length _________

(g) Total Leg Length ___________

(h) Chest Circumference __________

(i) Torso Length (Shoulder Height) ________

WORK SHEET

Appendix B

Phase I Non-Destructive Inspection

Helmet Data: (1) Manufacturer

(2) Model

(3) Serial No.

(4) Date of manufacture

(5) Type of fitting (Pads ____ Form Fitted ____)

If pads then list type and location

(a) Frontal

(b) Crown

(c) Parietal

(d) Ear Pads

(6) Visor Up ______ Down ____

(7) Was helmet recovered with the crewmember?

Yes _____ No ______

(8) Was helmet recovered separately?

Yes _____ No ______

(9) Helmet was lost / discarded (circle one)

(10) Modicications (a) Yes __ No ___

(b) Authorized Yes __ No ___

(c) Description of helmet mounted equipment with photographs as indicated in appendix F.

(11) Damage to the helmet Yes __ No ___

Indicate damage by circling in the photographs above. Describe damage and use closeup photographs as appropriate.

(12) If helmet was recovered without the crewman: (a) Was oxygen mask attached?

one side _______

both sides _______

not attached __________

both sides loose ________

(b) Was tissue present in/on helmet? Yes __ No ___

(13) If the helmet was lost which phase was it lost?

Appendix C

WORK SHEET

Phase II Non-Destructive Laboratory Inspection

A. All data obtained from Phase I observations plus additional general information:

1. Shipped from:

2. Date shipped:

3. Date received:

B. Inspection Procedures

1. Coherent Light Inspection (Photograph as required to document damage pattern)

a. Light wavelength

b. Light intensity

c. Lens size (aperature)

d. Focal distance from item

2. Infra-red Light Inspection

a. Light wavelength

b. Light intensity

c. Lens size (aperature)

d. Focal distance from item

3. Microscopic Inspection of Damaged Area

a. Macroscopic Inspection

b. Scanning Electron Microscopic Inspection

C. Comparison of Damage and Injury - (e.g. trauma/injury site to damage pattern on helmet; tissue and blood type)

WORK SHEET

Appendix D

Phase III Destructive Laboratory Inspection

A. Phase I & II inspection data evaluated prior to further inspection.

   1. Microscopic section of damaged areas for evaluation of the extent of damage to the site and further chemical analysis on the helmet or other sub structures if required.

   2. Chemical analysis as required

B. Other inspection and test procedures which could be required in specific cases:

   1. Impact test to duplicate damage patterns using a like item.

   2. Windblast test to duplicate the damage to the item and materials using comparable items.

   3. Controlled drop testing of comparable items.

   4. Micro-analysis of the components of the item.

Appendix E

GENERAL HELMET INVESTIGATION CHECKLIST FOR AIRCRAFT MISHAPS

1. Was the equipment used? Yes___ No___

2. Did the equipment function as designed? Yes___ No___
   (If no, go to 6)

3. Did the equipment interact with other equipment? (If yes, go to 9) Yes___ No____

4. Was the equipment damaged? Yes___ No____
   (If no, what is the disposition of the equipment?)

5. Could the equipment be considered as suitable for re-use? (Exclusive of instructions governing re-use/non re-use. If no, please explain and give your rationale.) Yes___ No____

6. Was there sufficient altitude/time to allow for successful ejection/functioning of the of the system? Yes___ No___

7. Was the ejection sequence terminated by ground impact? Yes____ No____

8. Was the ejection sequence retarded/delayed by other actions? (If yes, explain) Yes___ No___

9. Was dynamic interaction indicated by injury to the aircrew/ damage to the helmet? Yes___ No___
   (If yes, explain and give rationale and indications!)

10. How was this interaction determined? Give logic tree which you used to determine the associated damage/injury and the interaction; give evidence of what other equipment was involved and what was the indications?

11. Was the damage indicative of interactions? Yes____ No____
    (If yes, describe)

12. Was there damage to the helmet prior to the accidnet? (If yes, describe and advise how this was determined!) Yes____ No____

13. Does the damage pattern on the helmet align with any injury of the aircrewman? (If yes, describe using the attached charts!) Yes___ No_____

14. Does the equipment indicate abuse (e.g. pre-emergency or as the result of the emergency) treatment? (If yes, describe and give rationale for this determination!) Yes___ No_____

15. Was there indications of equipment deterioration? (If yes, describe type!) Yes___ No___

16. Was any predisposing problems discovered with the equipment which could contribute to failure? Yes___ No___

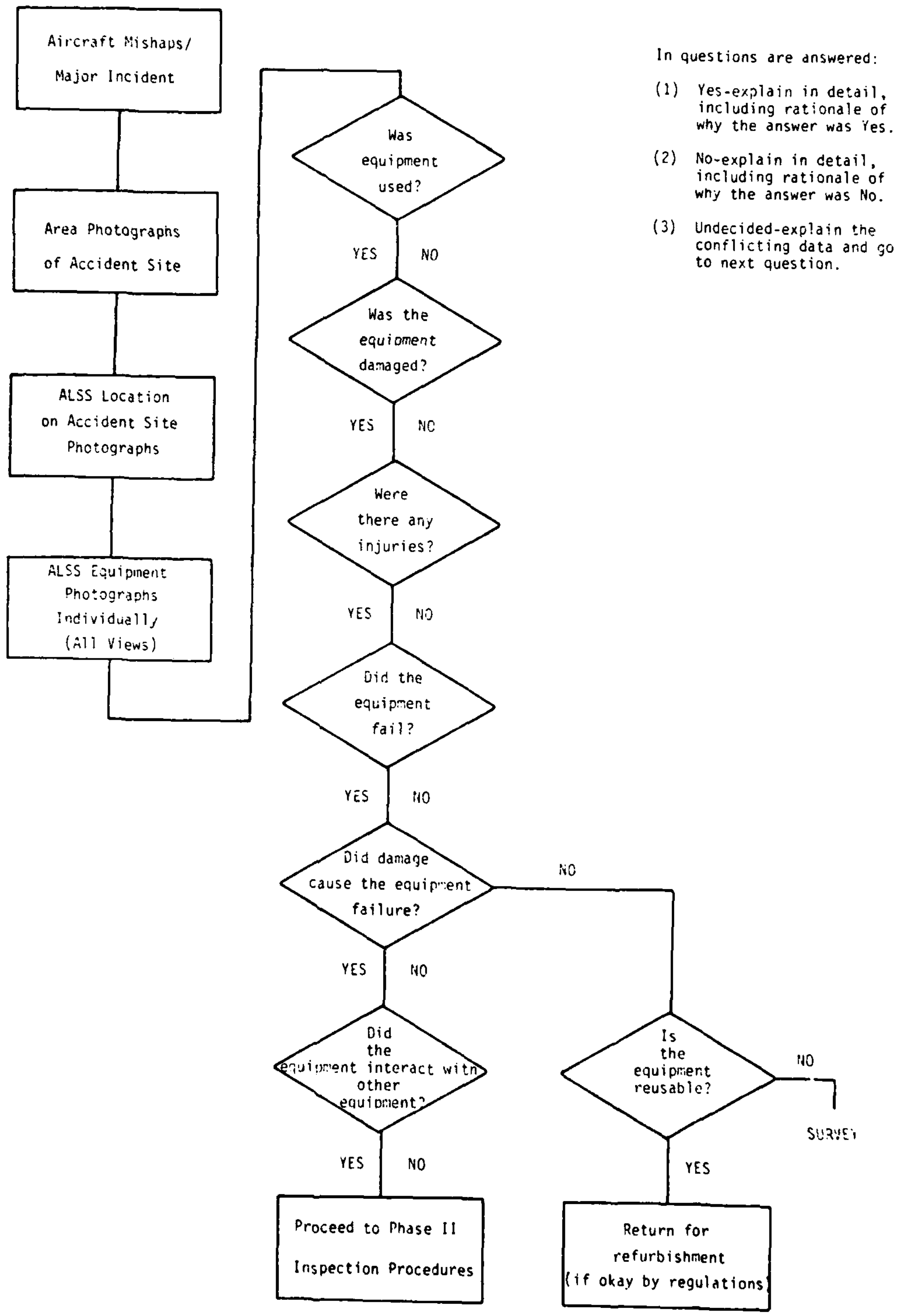
17. Was the equipment age limited; If so, was it within its useful life span? Yes___ No___
Date of mfg.___________ Manufacturer___________________

18. Had the equipment been inspected routinely? Yes___ No___
Date of last inspection__________ Inspector___________

19. Were any predisposing medical problems with the aircrewman? (If yes, describe fully even slight symptoms!) Yes___ No___

20. Should further analysis of the equipment be undertaken? (If yes, please specify rationale and which procedures would be helpful!) Yes___ No___

AIRCREW LIFE SUPPORT SYSTEM (ALSS)
INVESTIGATION FLOW



In questions are answered:

(1) Yes-explain in detail, including rationale of why the answer was Yes.

(2) No-explain in detail, including rationale of why the answer was No.

(3) Undecided-explain the conflicting data and go to next question.

APPENDIX F

SAMPLE PHOTOGRAPHIC VIEWS

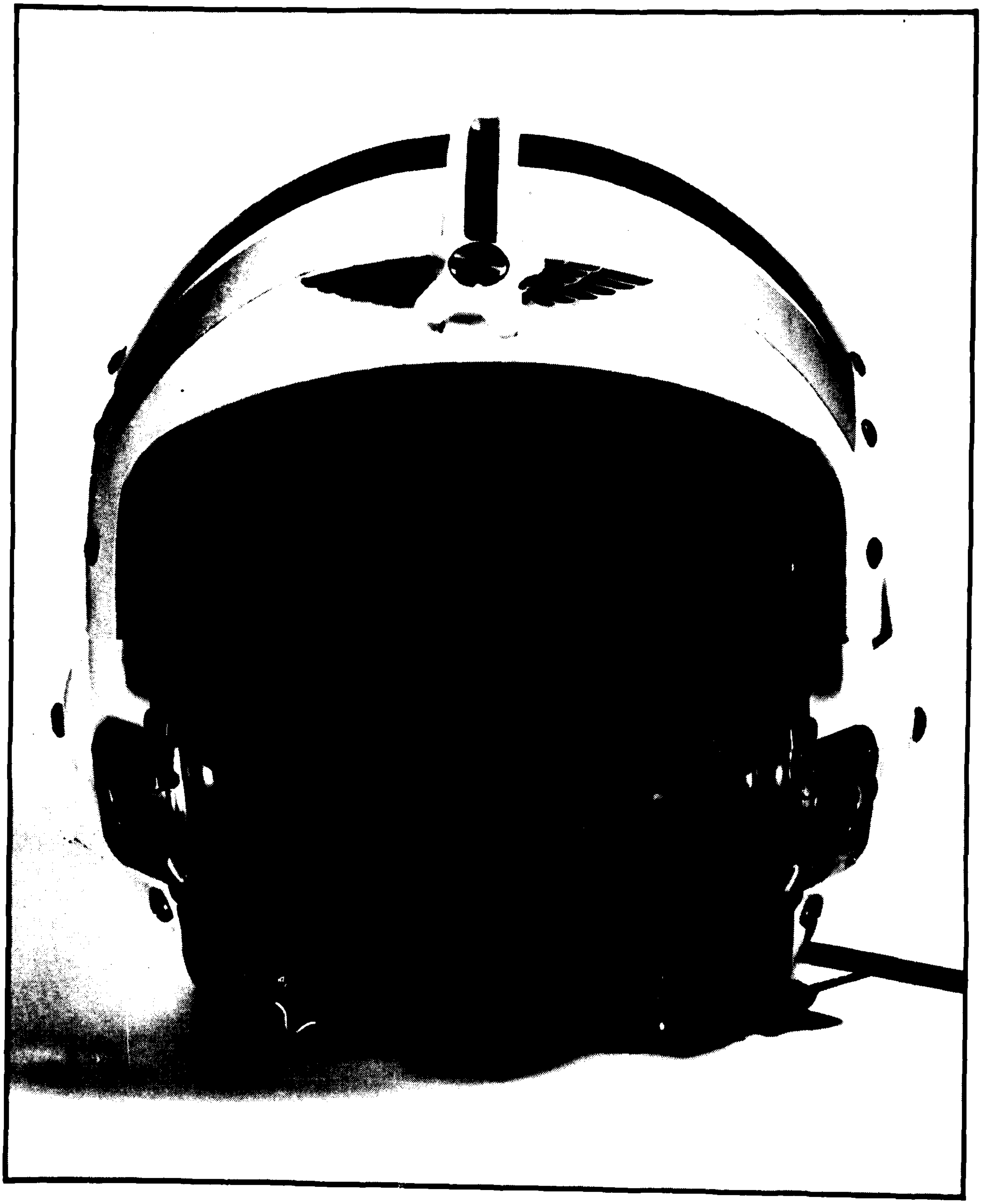


Figure 1. Helmet Visor Down Front
(light background)

Figure 1A. Helmet Visor Down Front (dark background)

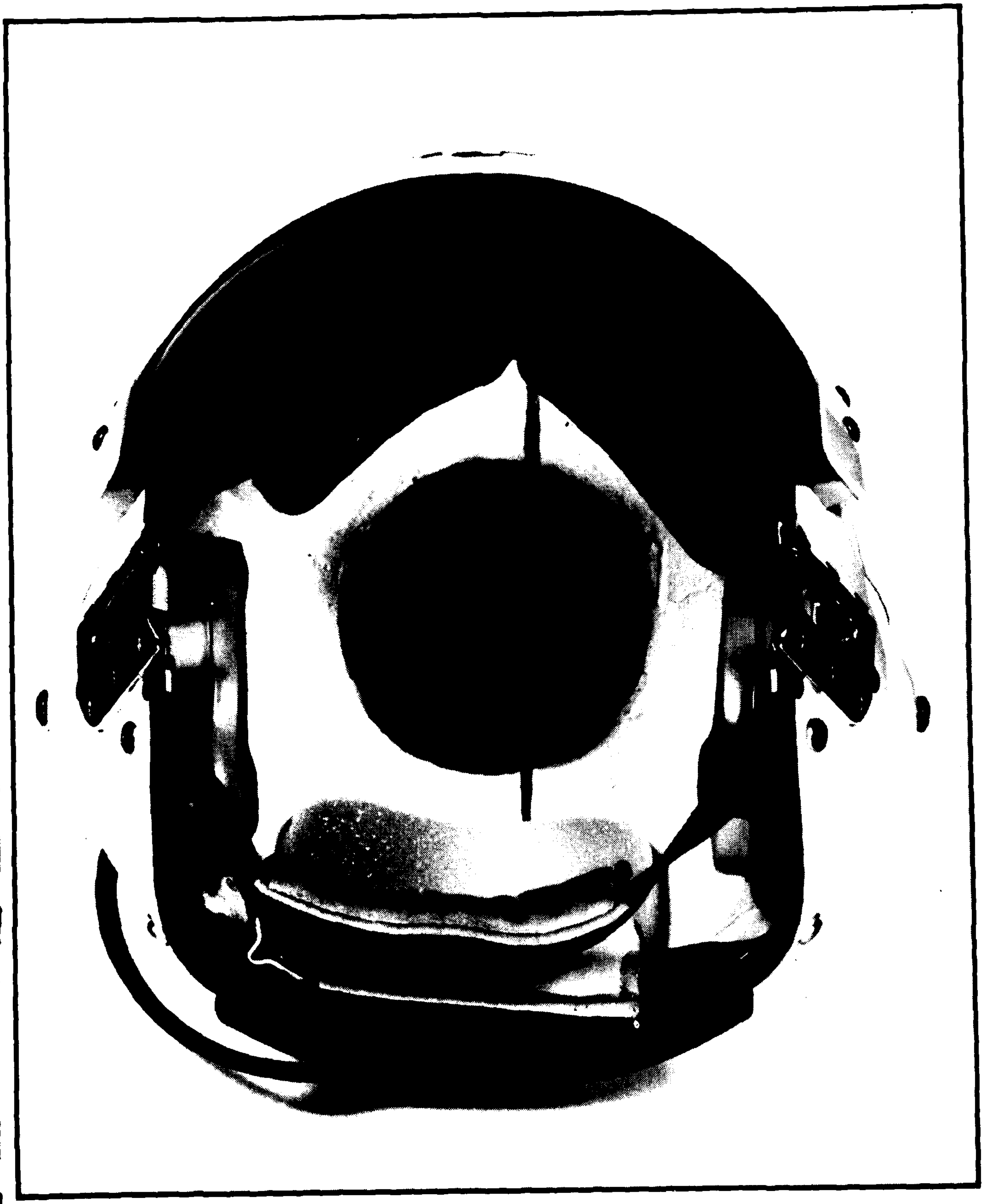


Figure 2. Helmet Visor Down Bottom
(light background)

Figure 2A. Helmet Visor Down Bottom
(dark background)

Figure 3. Helmet Visor Up 45° left
(shows right side)

Figure 3A. Helmet Visor Up 45° left
(shows right side)

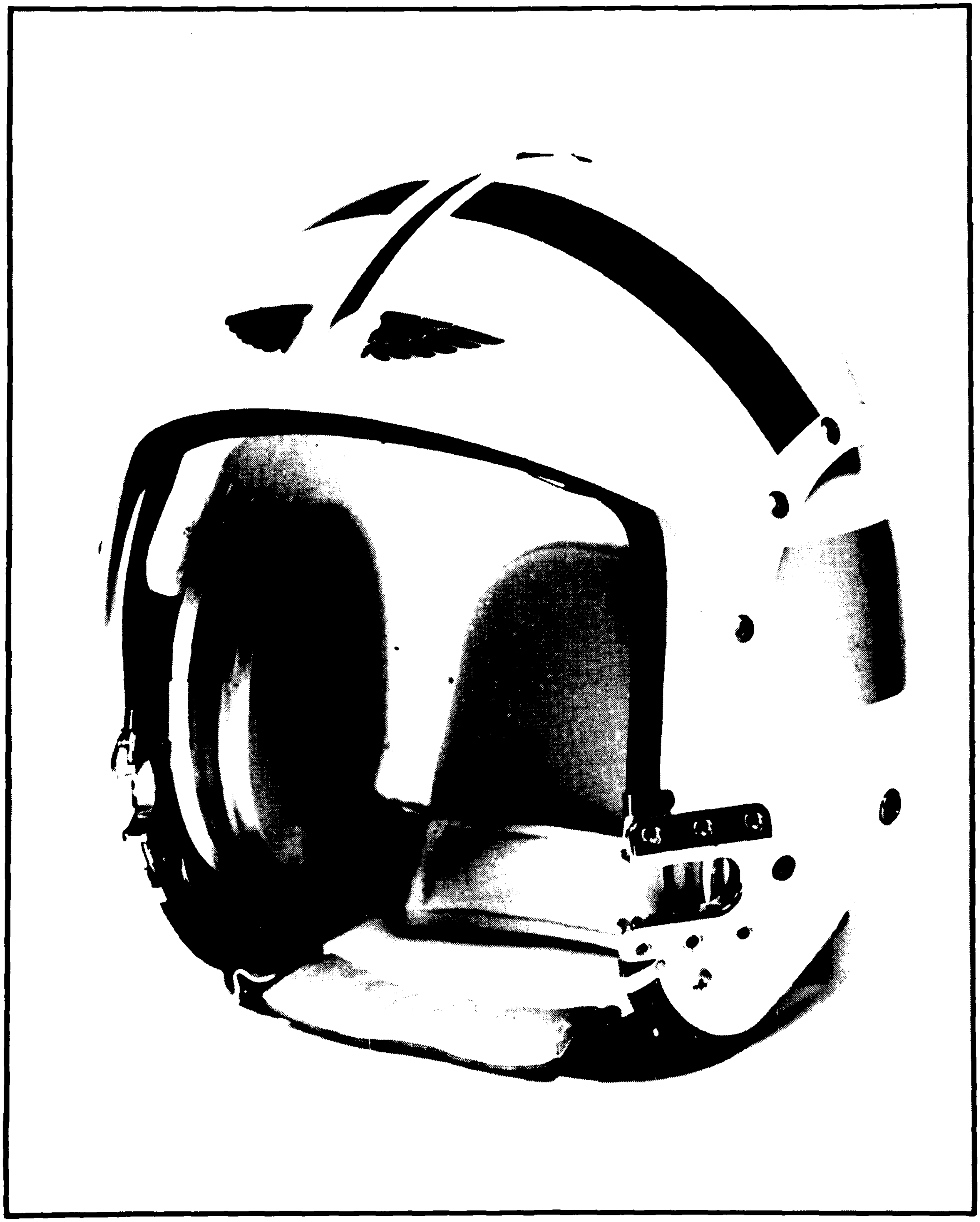


Figure 4. Helmet Visor Up 45° right
(shows left side)

Figure 4A. Helmet Visor Up 45° right
(shows left side)

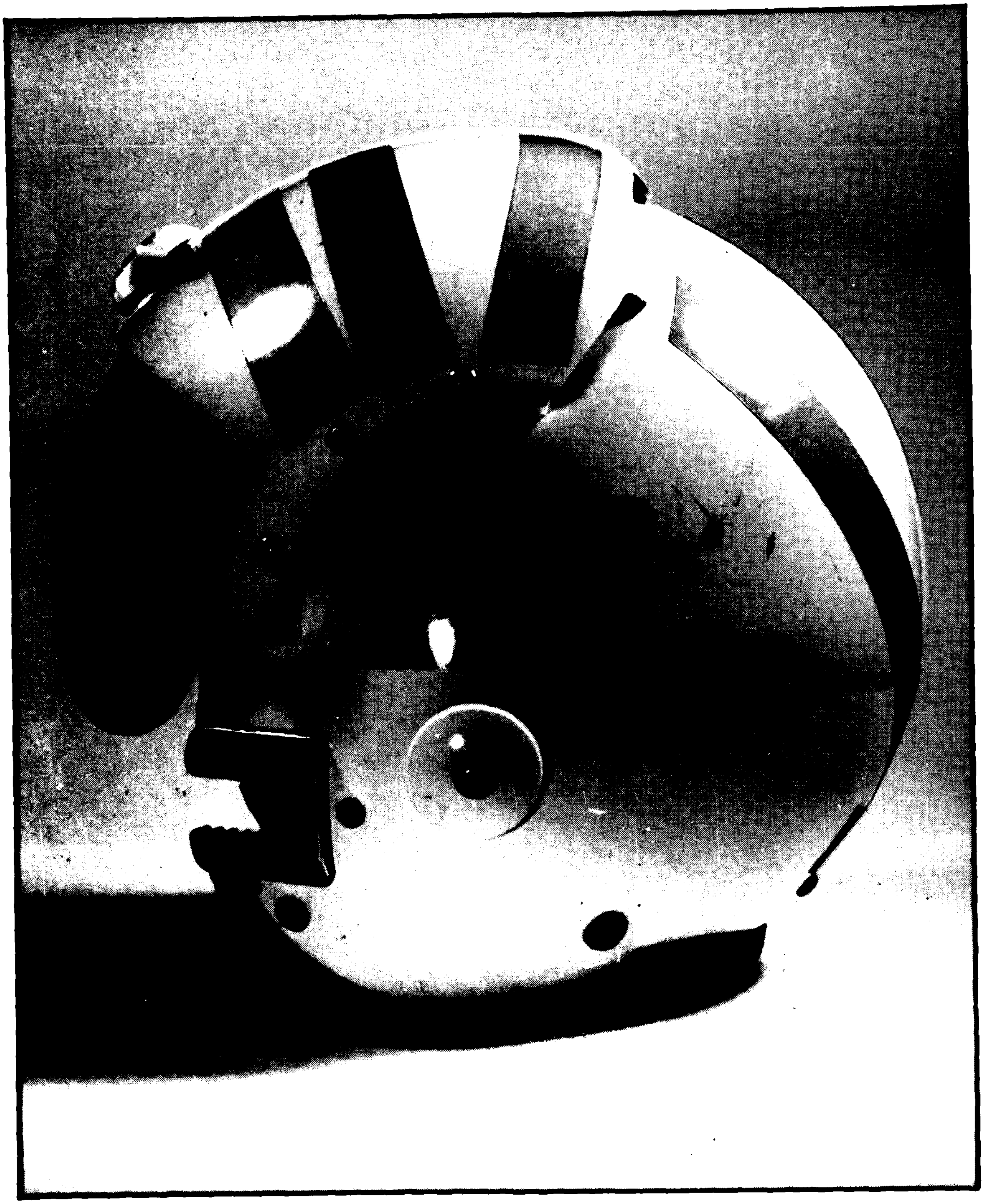


Figure 5. Helmet Visor Down Left Side
(light background)

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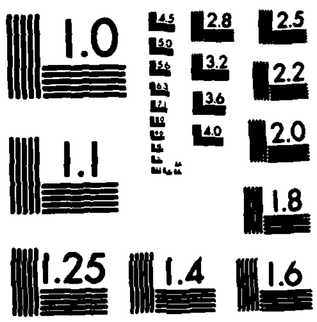


:CROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

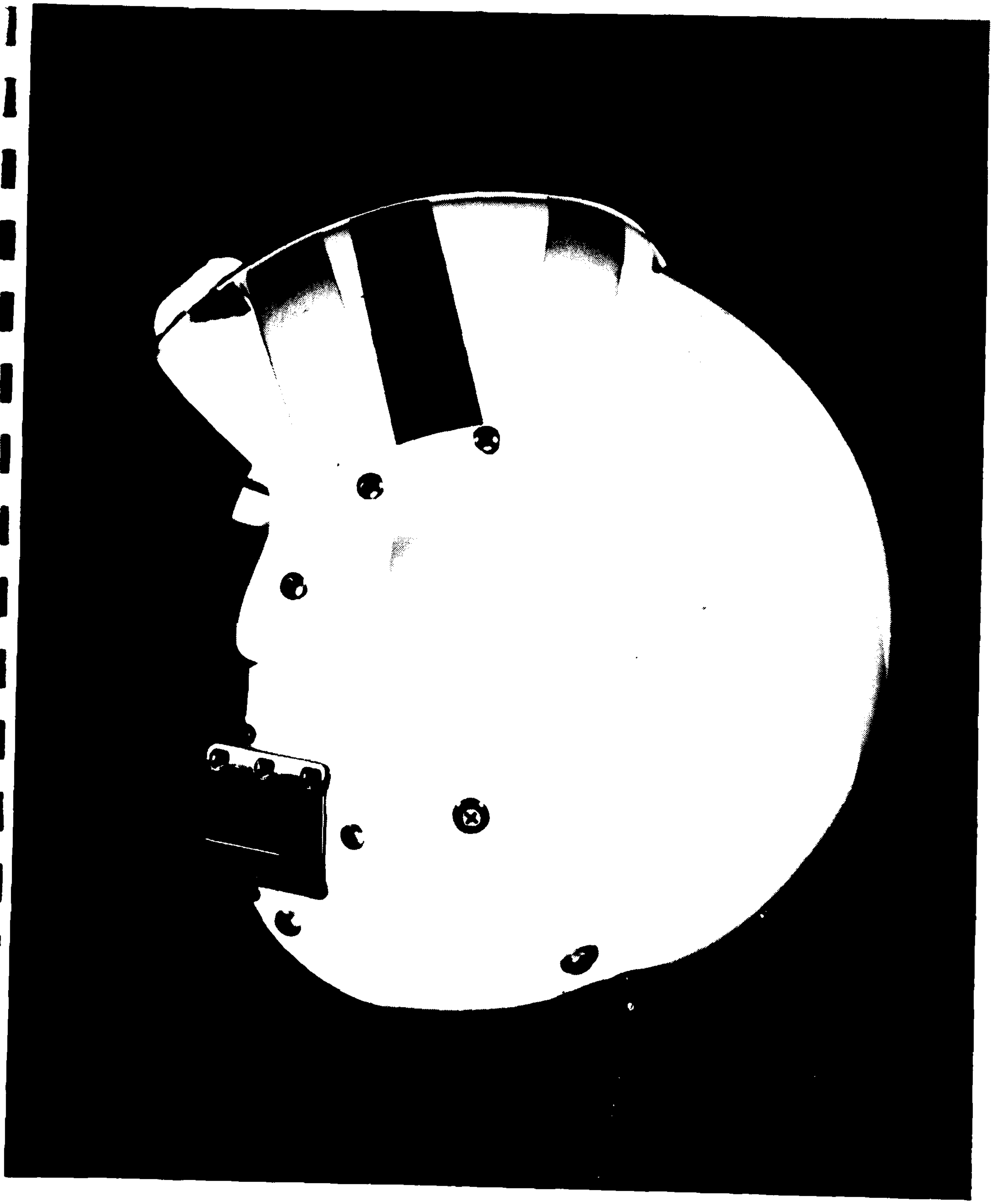


Figure 5A. Helmet Visor Down Left Side
(dark background)

Figure 6. Helmet Visor Up Bottom
(light background)

Figure 6A. Helmet Visor Up Bottom
(dark background)

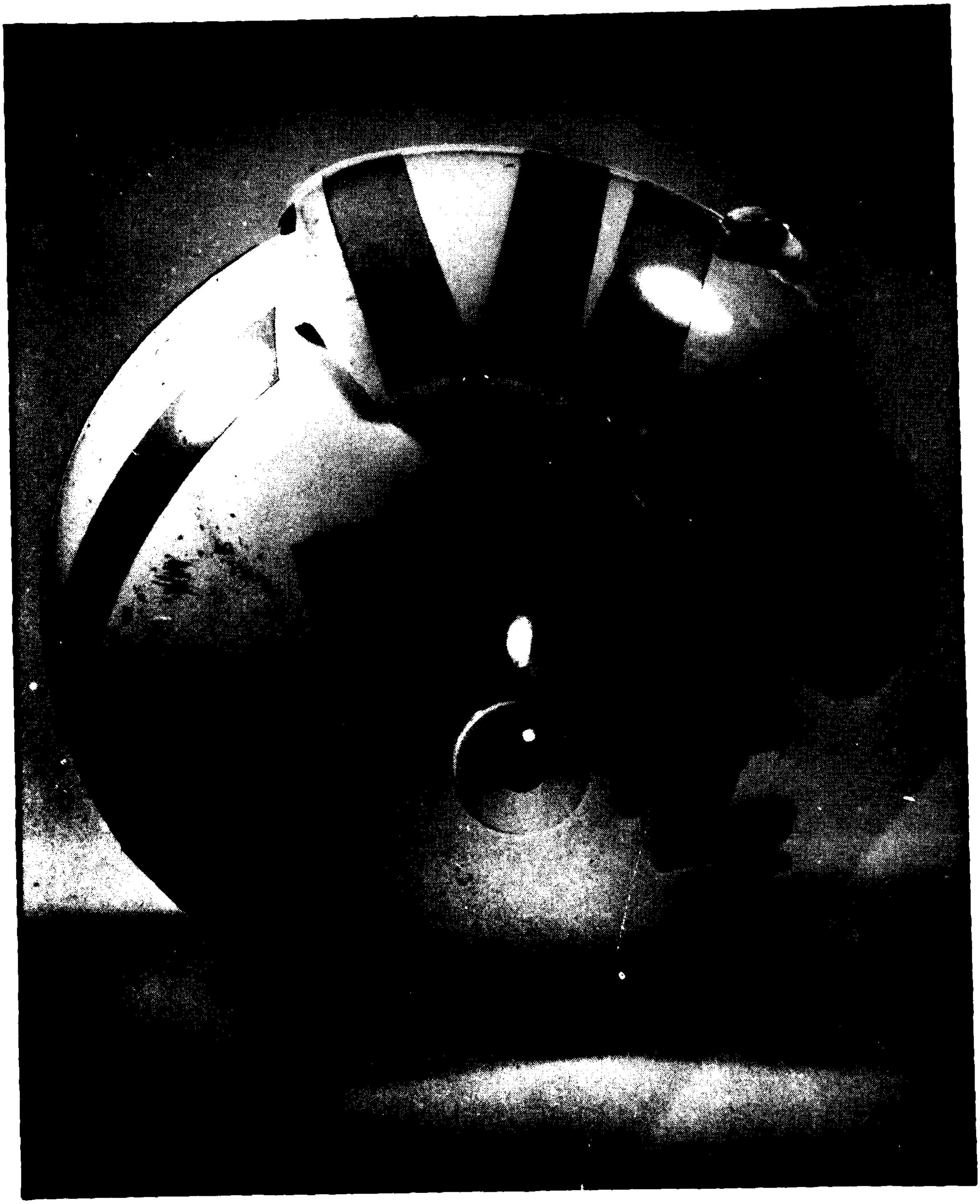


Figure 7. Helmet Visor Down Right Side (light background)

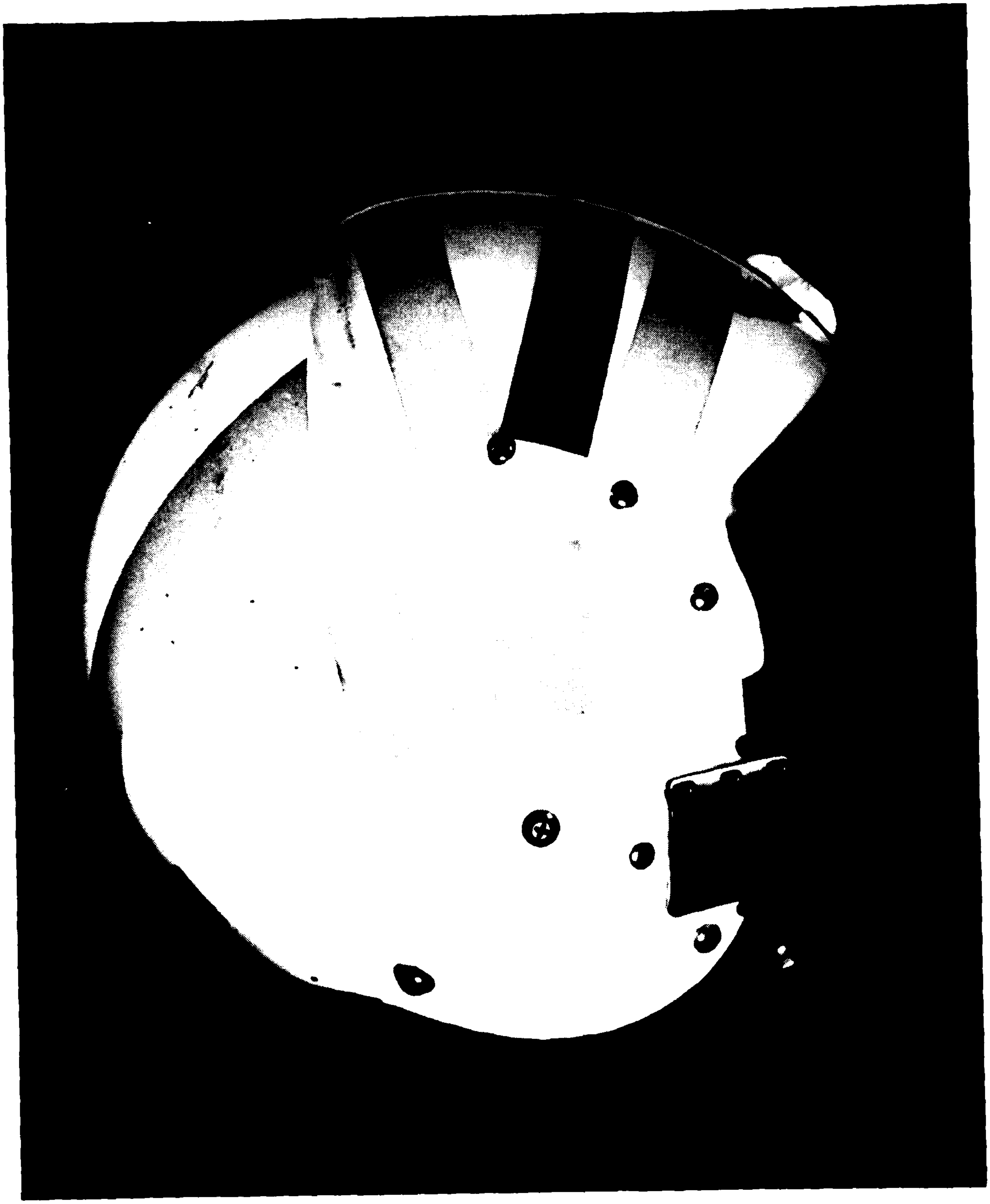


Figure 7A. Helmet Visor Down Right Side
(dark background)

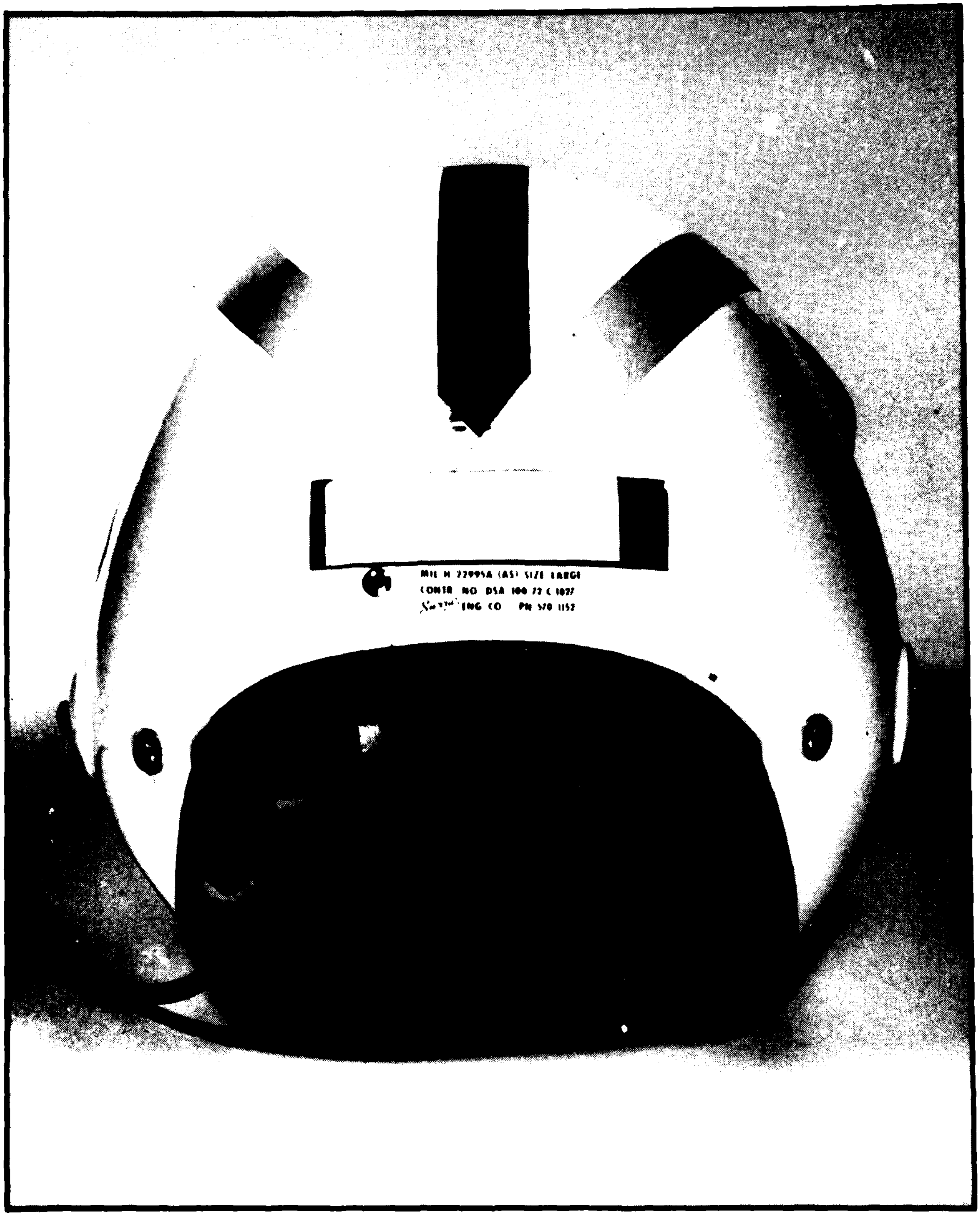


Figure 8. Helmet Rear View

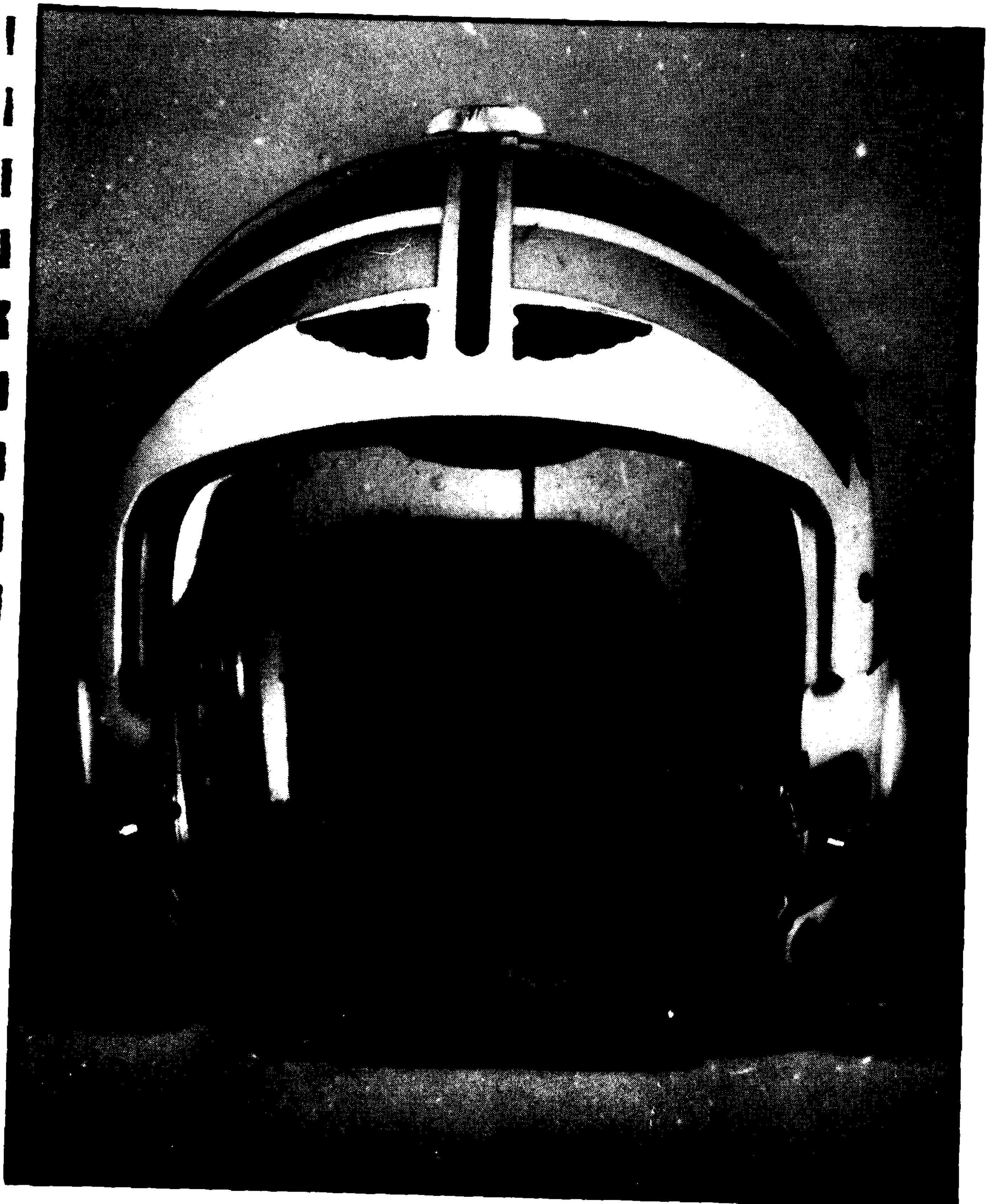


Figure 9. Helmet Visor Up Front
(light background)

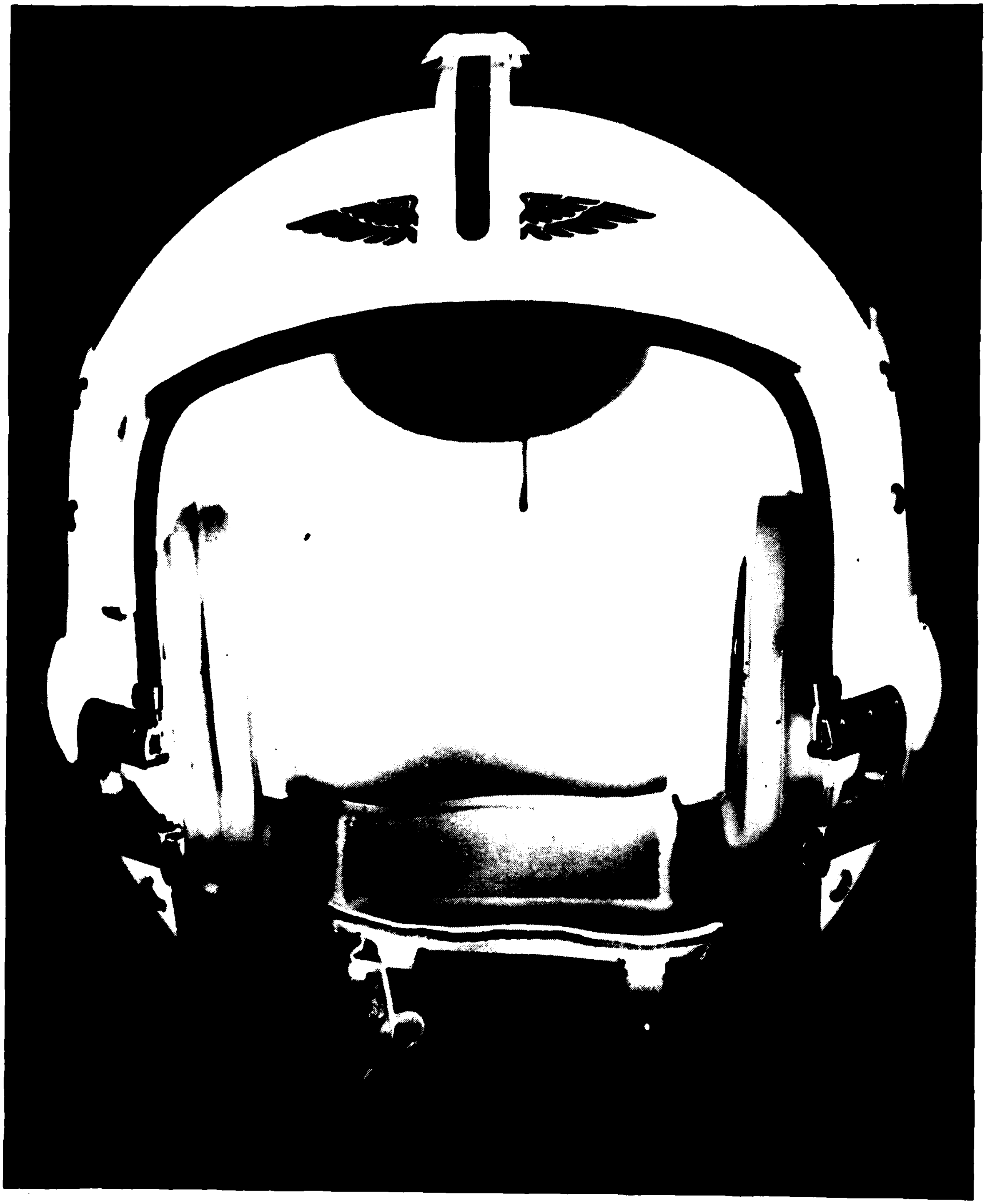


Figure 9A. Helmet Visor Up Front
(dark background)

Figure 10. Helmet Top View

Aircrew Life Support Systems (ALSS), Post Emergency Usage Guides

Part II: Oxygen Equipment, Man-Mounted

INTRODUCTION

Military man-mounted oxygen system components are designed to serve several purposes: (1) provide life sustaining breathing gases during normal flight and emergency escape; (2) provide inflight communications through the microphone; and (3) provide enhanced helmet retention. Additionally, the mask provides facial protection during the initial stages of emergency egress. Indepth assessment of the performance of the entire man-mounted oxygen system (oxygen mask, retention assembly, upper hose assembly, regulator, lower hose assembly, and the connector block assembly) is required to determine the dynamic interactions of these components and other life support equipment during aircraft mishaps and emergencies. An improved understanding of these interactions and the effects upon the aircrewman under diverse conditions associated with aircraft mishaps will provide the basis for improving the man-mounted equipment designs and the testing and evaluation process.

The enhanced data base is provided through detailed inspection of all man-mounted oxygen equipment and subcomponents involved in aircraft mishaps. This data will provide the background information to develop dynamic test and evaluation guidelines as well as improved design criteria for future equipment. To accomplish this data gathering, each subcomponent should be inspected for damage, displacement, malfunction, and indications of interactions with other equipment (e.g. paint, fibers) during the dynamic events of the mishaps.

The evaluation is not just the functioning of the equipment items but must be related to evidence of injury or injury prevention. It is vital to determine the conditions associated with the mishap to assess the interactions and determine casual effects. An example would consist of the oxygen mask being lost and the aircrewman reported to have facial lacerations; it is important to know (only if established fact, guesses and hypothesis should be identified and the rationale explained), if the mask was attached securely to the helmet and the patterns of the facial laceration; it is necessary to know when the loss was first experienced. Another example would be damage to the helmet bayonet fittings which could provide indications of dynamic involvement with the parachute or debris.

Further it is desirable to inspect the interior of the oxygen mask, performance of the regulator, and the hoses to determine if the aircrewman might have experienced physical difficulties prior to the actual emergency (e.g. blocked airflow, motion sickness). This handbook provides general guidance for Phase I and Phase II inspection procedures for the man-mounted oxygen system components and includes a data worksheet format for supporting the documentation of the mishap. The information contained on the man-mounted oxygen equipment: (1) will be combined with all available testing and mishaps data; (2) shall be provided to the investigating medical officer for the aircraft mishap; and (3) will be employed to update design criteria and quality assurance assessment standards for man-mounted oxygen equipment and subcomponents.

The inspection procedures established by this document have been implemented by the enclosed OPNAVINST and its amendments which provide for systematic acquisition and analysis of aircraft mishaps data to develop information for reducing potential risks to the aircrewman. Failure to completely institute systematic "in-service" data acquisition and analysis can result in valuable data being overlooked and lost thereby introducing bias into the informational system.

The issuance of the Handbook is accompained by the enclosed OPNAVINST which requires that all man-mounted oxygen equipment employed in ejections or other aircraft mishaps be subjected to systematic inspection designed to provide: (1) full documentation of the conditions associated with the oxygen equipment's usage; (2) identification and cataloging of the damage to the man-mounted oxygen system and its components; (3) comparison of the damage under varying conditions; (4) comparison of the injury patterns resulting under comparable conditions with the associated damage patterns; and (5) determination of the protective efficiency of the man-mounted oxygen system's components in preventing injurious conditions. This OPNAVINST, also sets forth conditions where Phase III Destructive Inspection procedures are necessary and what types of procedures might be employed.

Should Phase III inspection be indicated, guidelines for shipping of the equipment will be provided and the appropriate destination indicated. Receipt of the equipment will be acknowledged using a form letter which will contain the receipt of the equipment, indicate the time in which a response can be expected, and the inspection procedures to be employed.

Work Sheet

Appendix A

A. Data required for all life support equipment

1. Date of accident   Accident I.D. No.

2. Type of aircraft   Bureau No.

3. Location of accident

4. Ejection   Yes____   No____

   If yes: a. Altitude

   b. Airspeed

   c. Attitude

   d. Ejection seat type Ser. No.

   e. Crew station

   f. Parachute

   g. Survival kit type

   h. Reported winds aloft in area

   i. Landing site

5. Crash (occupied)   Yes____   No____

   a. Altitude of impact site

   b. Estimated airspeed at impact

   c. Estimated attitude at impact

   d. Impact site (ground - water - flight deck)

   e. Wind conditions

B. Injuries Sustained: Fatal_____   Nonfatal_____

1. Overall injuries reported (FSR):

2. Specific injuries: (a) Head fx   Yes____   No____

   (b) Neck fx   Yes____   No____

(c) Neck strain/sprain Yes__ No__

(List type and location of injuries using anatomical landmarks. Describe how the injury was determined - X-ray, postmortem, etc.)

C. Personal data: (1) Age ____ Blood Type ____

(2) Sex ____

(3) Weight ______

(4) Height ______

(5) Anthropometric Measurements

(a) Total Sitting Height _____

(b) Neck Circumference _______

(c) Cervical Length (C1 thru C7) ________

(d) Head Circumference _________

(e) Buttock Knee Length ________

(f) Buttock Popiteal Length _________

(g) Total Leg Length ___________

(h) Chest Circumference __________

(i) Torso Length (Shoulder Height) ________

Work Sheet

Appendix B

Phase I Non-Destructive Inspection

Oxygen Mask: (1) Manufacturer

(2) Model

(3) Date of Manufacture

(4) Was the oxygen mask recovered with the helmet?

Yes____ No____

(5) Was the oxygen mask attached to the helmet?

Yes____ No____

(6) Was the hose/mask assembly recovered?

Yes____ No____

(7) Was the hose/mask assembly damaged?

Yes____ No____

(8) Was the mask recovered with the aircrewman?

Yes____ No____

(9) Were any facial laceration/injuries indicated?

Yes____ No____

(If yes, describe using drawings and/or photographs)

(10) Is the hose/mask operable?

Yes____ No____

(If no, describe why it is not operable)

(11) If oxygen mask/hose assembly was lost, when was it lost?

(Deliberate discard or inadvertent. Describe in detail)

Work Sheet

Appendix C

Phase II Non-Destructive Laboratory Inspection

A. All data obtained from Phase I observations plus additional general information:

1. Shipped from:

2. Date shipped:

3. Date received:

B. Inspection Procedure

1. Microscopic examination mask assembly

a. Macroscopic inspection

b. Internal inspection

c. Fittings to helmet

2. Infra-Red light inspection

a. Light wavelength

b. Light intensity

c. Lens size (aperature)

d. Focal distance from item

3. Coherent light inspection

a. Light wavelength

b. Light intensity

c. Lens size (aperature)

d. Focal distance from item

C. Damage/Injury Comparison - (Tissue damage, present or absent in oxygen mask assembly. Where? Indicate using drawings.)

Work Sheet

Appendix D

Phase III Destructive Laboratory Inspection

A. Phase I and II inspection data evaluated prior to further inspection.

B. Other procedures and inspections which may be required.

1. Duplicate injury equipment pattern using windblast or impact tests.

2. Micro analysis of the components of the item.

Work Sheet

Appendix E

General Oxygen Mask Assembly Investigation Checklist for Aircraft Mishaps

1. Did the quipment interact with other equipment? (Describe what indicated the interaction.) Yes____ No____

2. Could the equipment be considered suitable for reuse? (Exclusive of the interaction governing use/reuse. If no, please explain and give your rationale.) Yes____ No____

3. Was the equipment interaction a contributor to the injuries sustained by the aircrewman? (Describe what leads you to either answer.) Yes____ No____

4. How was the interaction determined? (Describe in detail the steps you used to arrive at your conclusion.) Yes____ No____

5. Was the damage indicative of interactions? (Describe your logic.) Yes____ No____

6. Does the damage reflect injury to the aircrew? (Describe using drawing, photographs and words to support your decision.) Yes____ No____

7. Were any predisposing problems with the equipment which could contribute to the mishap? (Explain if yes.) Yes____ No____

8. Was the equipment age limited? If so, was it within its useful life span? Yes____ No____

   Date of mfg. __________ Manufacturer ____________________

9. Had the equipment been routinely inspected? Yes____ No____

   Date of last inspection ________ Inspector ____________________

10. Did the aircrewman have any predisposing medical problems? (If yes, describe the symptoms.) Yes____ No____

11. Should further inspection of the equipment be undertaken? (If yes, explain why and give your reasons. What procedures would you suggest may be helpful?) Yes____ No____

AIRCREW LIFE SUPPORT SYSTEM (ALSS)

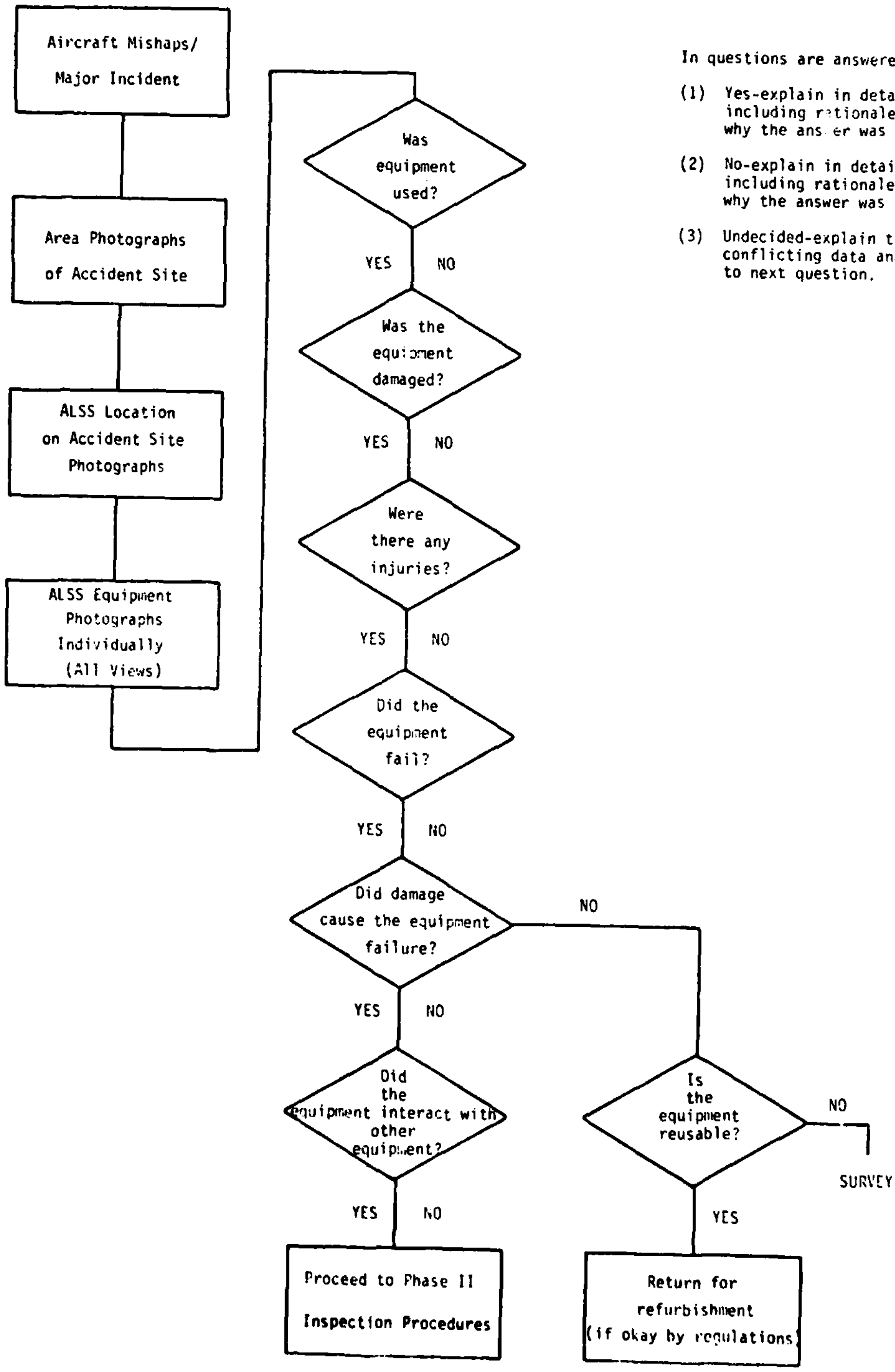
INVESTIGATION FLOW

In questions are answered:

(1) Yes-explain in detail, including rationale of why the answer was Yes.

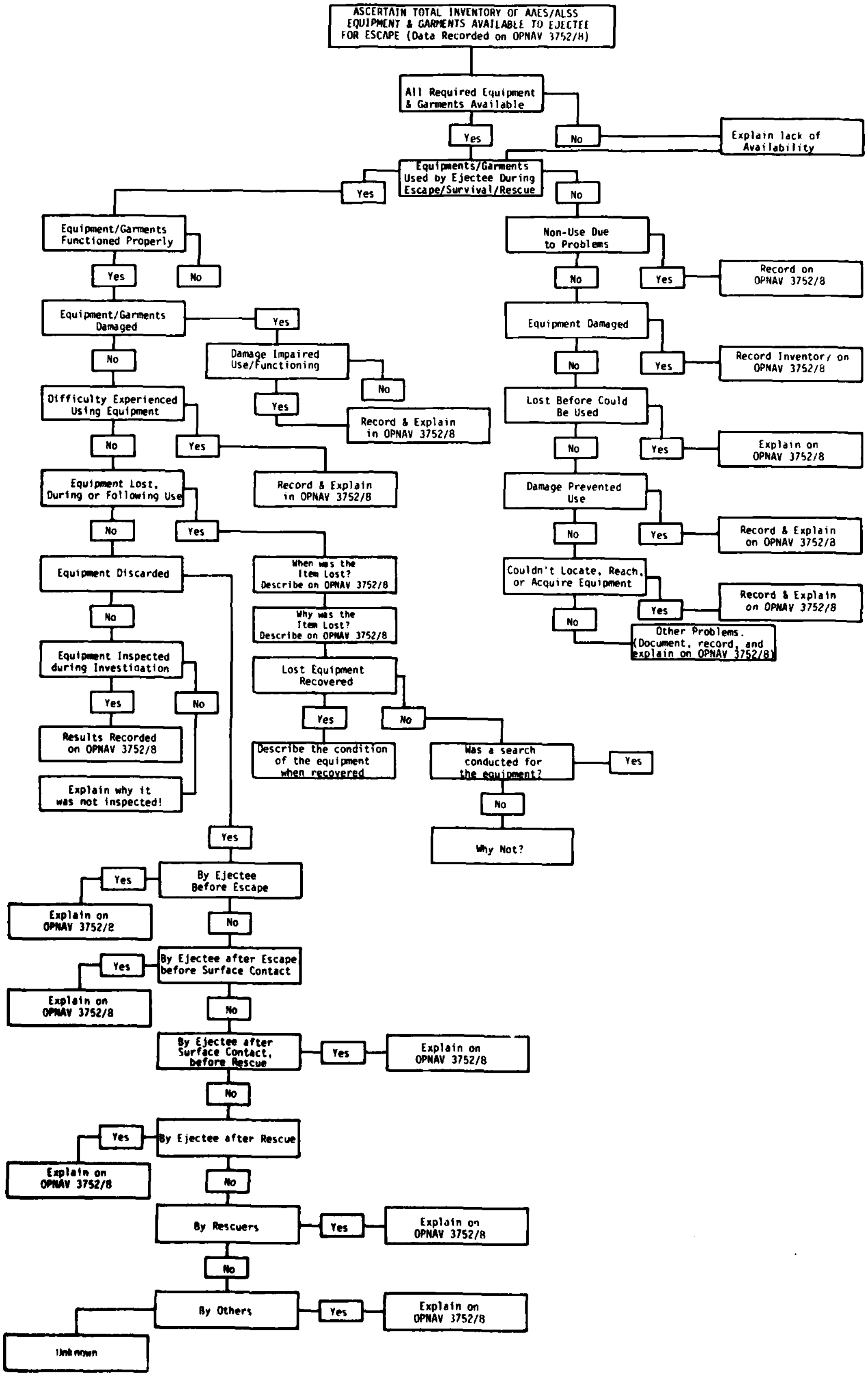
(2) No-explain in detail, including rationale of why the answer was No.

(3) Undecided-explain the conflicting data and go to next question.



Aircrew Life Support Equipment Post-Usage Investigation/Reportage Generic Decision Tree

AIRCREW LIFE SUPPORT EQUIPMENT (ALSS) POST-USAGE INVESTIGATION/REPORTAGE GENERIC DECISION TREE



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Attended Albany State College in Georgia and Howard University in the District of Columbia as an undergraduate Social Science Major.

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James F. (Felix) Palmer received his bachelor's degree (B.S. in Bacteriology) from Louisiana Polytechnic Institute (Louisiana Tech University), Ruston, Louisiana in 1965. He received his master's degree (M.S. in Biology-Marine Biochemistry) from University of Alabama, Tuscaloosa, Alabama in 1970.

He has been employed in various areas of research since receiving his bachelor's degree; Southern Research Institute in Birmingham, Alabama; National Parachute Test Range in El Centro, California; and Naval Aerospace Medical Research Laboratory, Pensacola, Florida.

Mr. Palmer has been an active member of the U.S. Navy in both an enlisted and commissioned status since 1969. His duty stations have included recruit training of RTC Orlando, Florida; hospital corpsman training at Hospital Corps School, Great Lakes, Illinois; laboratory technician at the Naval Regional Medical Center in Jacksonville, Florida; student aerospace physiology training at the Naval Aerospace Medical Institute in Pensacola, Florida; research aerospace physiologist at the National Parachute Test Range in El Centro, California; staff aerospace physiologist at the Naval Aerospace Medical Institute in Pensacola, Florida; research aerospace physiologist and director of planning and programming at the Naval Aerospace Medical Research Laboratory in Pensacola, Florida.

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Employed in Crew Systems Division, Naval Air Systems Command, Washington, D.C., as a senior technical assistant to the Assistant Director of the Division. Served as project engineer, directing several programs to incorporate ejection seats into Navy aircraft, including YANKEE in A-1H/J, MK GRU7A in F-14, ESCAPAC ID-1 in X-22A, and SIIIS-3 in AV-8A. Authored MIL-S-18471B through F and MIL-E-9426B through F; specifications for U.S. Navy ejection seat type AAES and for evaluating and testing those systems, respectively. Currently the NAVAIR project engineer for the aircrew automated escape systems (AAES) in-service usage data analysis program.

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